

HURRICANE NUMBER



Hurricane Number

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FALMOUTH FIRE DEPARTMENT IN ACTION DURING AND AFTER THE HURRICANE

RAY D. WELLS

Chief of the Falmouth Fire Department

At about 1:30 on the afternoon of September 21st, I noticed that the storm was increasing and that the barometer was dropping very rapidly. The wind gave us trouble on the fire alarm circuits. At about 2:12 a break in the line was reported, and a crew was sent out to attend to that. At 3:01 I ordered a crew to go down to Maravista to rescue a woman in a stalled car. The crew responded, and in the process of pulling the woman out they got their truck stuck. Another crew, immediately summoned, pulled both out.

Then I went to Maravista, where I met a lady running through the water. She told me that five women and two children were marooned in Oviatt's house. A crew in charge of Captain Ferris removed the women and children, among them an invalid and her nurse. Then Captain Ferris, with Captain Locke, Lt. Fisher, (Continued on page 26)

THE METEOROLOGICAL ASPECTS OF THE NEW ENGLAND HURRICANE

GARDNER EMMONS

Assistant Professor of Meteorology, New York University; Meteorologist, Woods Hole Oceanographic Institute

The tremendous rise of water, or "storm wave", that accompanied the hurricane was probably totally unexpected by most residents of the southern New England coast. It was this inundation, rather than the wind, which really caused the great loss of life and enormous damage to property. However, the storm wave has long been a well-recognized feature of hurricanes. Tannehill, in a recent book on hurricanes,* devotes an entire chapter to the phenomenon. He states that "more than three-fourths of all the loss of human lives in tropical cyclones has been due to inundations. The rise of the sea water over low coastal areas not subject to overflow by ordinary tides is sometimes sudden and overwhelming and in some situations there is no escape."

How applicable the above quotation is to this



STORM SIGNALS AT NOBSKA

At 4:15 P. M. half an hour before waves washed the bathhouse across the road into Fresh Water Pond.

Sept. 28, 1938, Woods Hole, Mass.

To the Members of the Corporation of the Marine Biological Laboratory:

From the articles in this issue of THE COLLECTING NET, you will learn that the Laboratory did not emerge scathless from the hurricane and tidal wave of September 21st. The damage, however, is not great relatively; and most fortunately no lives of our members were lost, as might well have happened earlier in the year. We owe a debt of gratitude to the members of the staff in all the operating departments for their loyal, unremitting efforts which minimized the losses. Some of our members have suffered serious property loss; to all of them we offer our sincere sympathy. To those residents of Woods Hole who have lost dear ones our hearts go out in neighborly sympathy.

The laboratory will open as usual in 1939.

(signed) FRANK R. LILLIE, *President.*



THE THUNDERING SURF MOUNTING THE SEA WALL NEAR THE BUREAU OF FISHERIES RESIDENCE IN WOODS HOLE.
(Copyright, L. A. Baker)

particular storm! But why was the region of severe inundation confined to a stretch of coast between Martha's Vineyard and the central part of Long Island? I quote further from Tannehill: "The true storm wave is not developed unless the slope of the ocean bed and the contour of the coast line are favorable. Like the gravitational tide, it reaches its greatest height in certain situations. If there is a bay to the right of the point where the cyclone moves inland, the waters are driven into the bay. With a gently sloping bed, the water is piled up by resistance and becomes a great wave or series of waves which moves forward and to the left, the principal inundation usually taking place on the left bay shore. Great storm waves which have taken an enormous toll of human lives have, so far as records are available, occurred in nearly every case in a situation of this kind."

Now the path of the storm, as shown in Figure 1, was to the west, that is to the *left* of Buzzard's Bay and Vineyard Sound. In addition, as is well known to oceanographers, the ocean bed to the south has a comparatively gentle slope. Thus the necessary conditions for the development of a storm wave are fulfilled. As Tannehill points out, the coincidence of the arrival of the storm wave with the time of the maximum height of the gravitational tide produces unprecedented high water.

We may now ask: Could the wave have been predicted in advance? The answer is: Yes, if the path that the cyclone center actually followed had been correctly anticipated. The occurrence of storm waves in connection with tropical hurricanes on the coast of the Gulf of Mexico is known to all experienced inhabitants as well as government meteorologists there, and the Weather Bureau always gives warnings of high water as part of its regular hurricane warnings in that section. Why was not such service rendered to the people of Southern New England? Thereby hangs a tale.

The first notice of the presence of the hurricane in tropical Atlantic waters was received by the Weather Bureau on Saturday, September 17th. On Sunday morning (September 18th) the following warning was issued by the Weather Bureau forecast center at Jacksonville, Florida: "Advisory 10:30 A.M., E.S.T. The tropical disturbance, probably of full hurricane intensity, is centered at 7:00 A.M., E.S.T., in approximately lati-

tude 22° 30' N., and longitude 62° W., apparently moving west or west-northwestward about 15 to 20 miles per hour. Caution is advised all vessels in the path of this dangerous storm."

On Monday morning (September 19th), the warnings ordered 9:30 A. M., from Jacksonville "Advisory 9:30 A.M., E.S.T., Northeast storm warnings ordered 9:30 A.M., from Jacksonville to Key West, Florida. The hurricane was centered at 7:00 A.M., E.S.T., in approximately latitude 23° 45' N., and longitude 70° 30' W., which is about 650 miles east-southeast of Miami, apparently still moving west-northwestward at least 20 miles per hour. The winds will increase in the Bahamas throughout the day, reaching hurricane force during the afternoon in outlying islands and *if present direction and rate of movement is maintained the storm will reach the southeast Florida Coast Tuesday morning with winds commencing to increase tonight. The Florida east coast is in the danger zone of this storm and all interests are urged to stand by for possible hurricane warnings during the day.*"

And on Tuesday morning (September 20th) the Jacksonville forecast center issued the following statement: "Advisory 9:30 A.M., E.S.T., Northeast storm warnings were ordered at 9:30 A.M., E.S.T., on the North Carolina coast between Wilmington and Cape Hatteras. The hurricane, which is of great intensity, was central at 7:00 A.M., E.S.T., near latitude 28° N. and longitude 75° W., which is about 300 miles east of Vero Beach, Fla., and it is now moving north-northwestward or northward about 17 miles per hour. *The storm will gradually turn toward the north-northeast with the center passing some distance east of Cape Hatteras tonight, and it will cause increasing northerly winds on the North Carolina Coast, becoming fresh to strong and probably reaching gale force at exposed places on the Cape, with hurricane winds some distance off shore. Caution advised all vessels in path, and all small craft from the Virginia Capes to Charleston should remain in harbor until storm passes. The lowest barometric pressure reported during the night was 27.90 inches.*"

The italics in the above warnings are mine. Note that on Tuesday it was stated by the forecaster at Jacksonville that "the storm will gradually turn toward the north-northeast with the center passing some distance east of Cape Hatteras tonight . . ." There was little justification for the belief that the storm would recurve so

* Tannehill, I. R., *Hurricanes*. Princeton University Press., Princeton, New Jersey, 1938.

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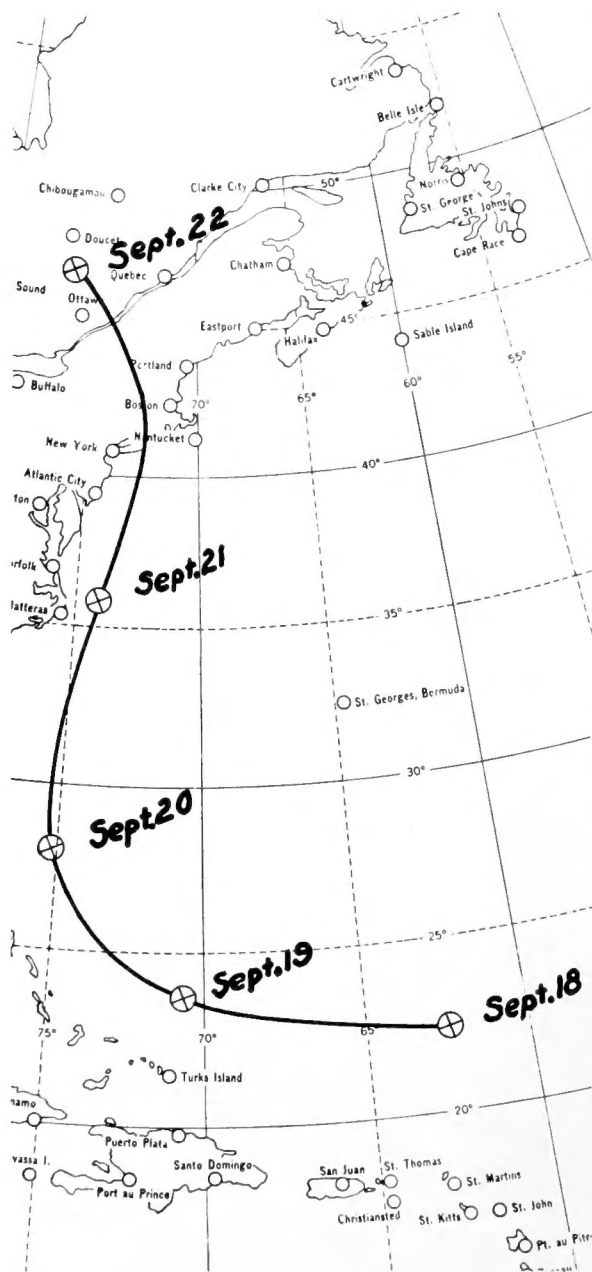


FIGURE 1.

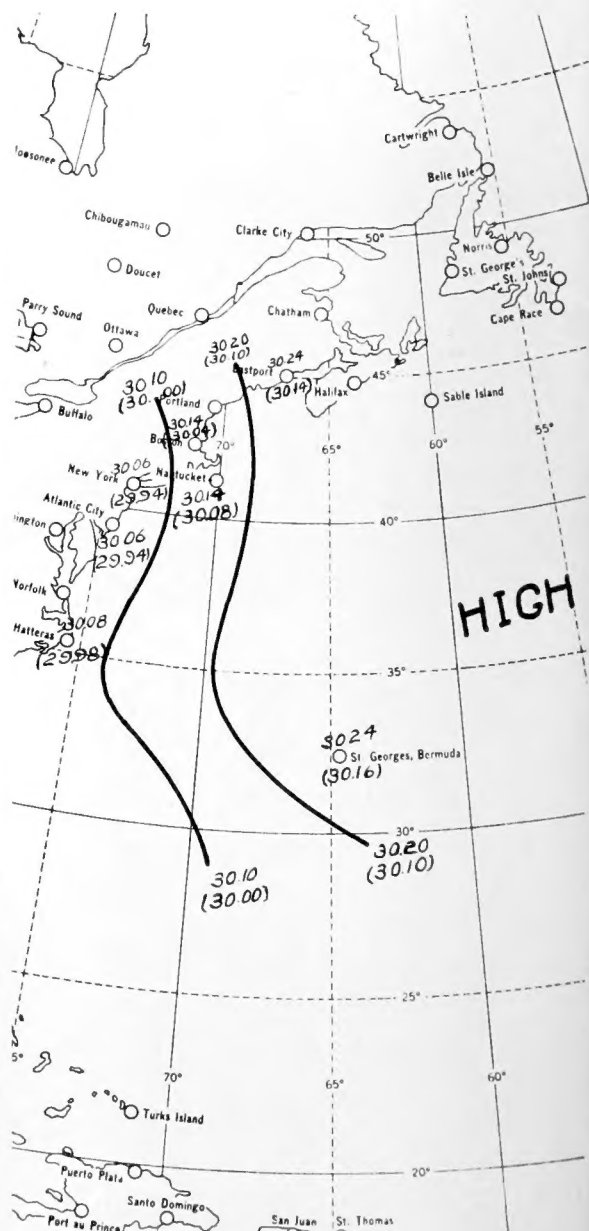


FIGURE 2.

DIAGRAMS SHOWING PATH OF HURRICANE AND SEA LEVEL ISOBARS

Figure 1: Path of the hurricane, showing the positions of the center at 7:00 A. M., E. S. T., September 18-22. Figure 2: Constancy of anticyclonic flow, as shown by the unchanged orientation of the sea-level isobars from September 19 to September 20. The upper figure reading on September 19, the lower figure that on September 20. Although a general fall of pressure took place during the intervals, the flow pattern remained the same.



WHEN WATER STREET LIVED UP TO ITS NAME!

Above: The M.B.L. Club House at the height of the storm, with the Woods Hole Oceanographic Institution behind it. The building between the two telephone poles at the left is Rowe's Drug Store, while that to the right of the Oceanographic building is the institution pump house. (L. A. Baker)

Below: A churning mass of wreckage tossing over the sea wall, photographed from the steps of the Yalden Sundial. At the extreme right is the M.B.L. pump house. On the horizon may be distinguished Lawyer Hathaway's yacht "Rosemay," which battled the storm successfully by running its engines at full speed throughout the hurricane. (L. A. Baker)

quickly. Figure 2 supports this contention. It shows the pattern of the sea-level isobars over the ocean just east of the Atlantic Coast on the morning of September 19th (Monday). The chief feature is the large anticyclone ("HIGH") centered to the northeast of Bermuda. Now it is a fundamental elementary fact that in northern latitudes the wind blows clockwise around an anticyclone, roughly parallel to the isobars. Therefore, it is seen that the general wind circulation was characterized by a broad current of air flowing westward in the region south of Bermuda, thence curving northward to the coast of Southern New England.

A further explanation of Figure 2 is necessary. The figures *un-enclosed* in parentheses beside several coastal stations are the barometric readings at 7:30 A.M. on Monday. Those *enclosed* in parentheses are the barometric readings at 7:30 A.M. on the following day (Tuesday). It is seen that the barometer has fallen approximately 0.10 inch at every station. Hence the 30.10-isobar of Tuesday is approximately coincident with the 30.20-isobar of Monday and the 30.00-isobar of Tuesday coincident with the 30.10-isobar of Monday. This simply means that there has been no appreciable change in the pattern of the surface air flow during the interval.

What bearing does this have on the path of the hurricane, which was skirting the Bahamas at this time? In the first place, a tropical cyclone is a comparatively small, though violent, cyclonic eddy, embedded in a slow drift of an anticyclonic eddy of much larger dimensions. A hurricane is analagous to a small whirlpool in a broad river or tidal current. It is carried in the direction of the general flow.

In the second place, there had been no appreciable change in the general flow from Monday to Tuesday, and the indications were that conditions would remain the same for another twenty-four hours. Therefore, it is difficult to see how the storm could have been expected to veer out to sea off Hatteras. It would have been more logical, as shown by Figure 2, to anticipate a movement straight up the Atlantic Coast.

It is a well-known rule-of-thumb that large stationary "Highs" have a "blocking" effect on tropical cyclones. In consequence, the latter are obliged to skirt around the edges of the anticyclones. In a detailed study of West Indian hurricanes published by the Weather Bureau, the following precept is laid down: "It is well understood that no tropical cyclone will recurve in the Atlantic Ocean or the Caribbean Sea so long as the more or less permanent anticyclone that extends from the vicinity of the Azores west-southwestward over Bermuda to the coast of the Uni-

ted States persists; it will be carried along in the general drift of the atmosphere at the higher levels, say from 3 to 5 kilometers above the surface, and it will skirt the southern edge of this anticyclone and recurve to the northward and northeastward around the western end of it."

In addition to the sea-level pressure situation already noted on Tuesday, September 20th, the movements of the intermediate clouds at stations along the Atlantic Coast was from south to south-southwest. These clouds may be taken to represent the drift at 3 to 5 kilometers above the surface. They show that the dominating anticyclonic circulation observed at sea level over the western Atlantic was maintained to high levels. In view of the facts, then, it must be concluded that the Jacksonville forecaster disregarded the rule.

At 7:00 A.M. on Wednesday the hurricane center was observed to be only a short distance east of Cape Hatteras. In this position it came under the jurisdiction, so to speak, of the Washington forecast center. The official synopsis of conditions issued from Washington at that time simply stated that "the tropical storm is central this morning about 75 miles east of Cape Hatteras moving rapidly north-northeastward. It is attended by shifting gales over a wide area and by winds of hurricane force over a small area near its center."

The marine forecast for the Eastport-to-Sandy Hook area read as follows: "Shifting gales, becoming northwest over south portion tonight and over north portion Thursday morning—." This suggested that the storm was expected to pass some distance to the south and east of Nantucket, giving mainly offshore winds on the southern New England coast. Hurricane winds evidently were not expected to extend to the coast line. Consequently, nothing but an ordinary storm warning was ordered at this time, a warning such as is ordered on ten or a dozen occasions every winter. No advices to interested parties to stand by for possible hurricane warnings were given out, as was done earlier in the week by the Jacksonville forecast center. At 11:30 A. M. (E.S. T.), when it was realized that the vortex was heading almost due north, the storm warning was changed to a whole-gale warning from the Virginia Capes to Sandy Hook (the whole-gale warning was never extended *east* of Sandy Hook). At least two hours before this later warning was issued, it was apparent to all observers in New York City who had an opportunity to watch the unbelievably rapid fall of the barometer that the hurricane was approaching Long Island. However, nothing could be done because authority to issue hurricane warnings is conferred only upon certain designated forecast



WRECKAGE WASHED ASHORE DURING THE STORM

Above: Looking toward the United States Bureau of Fisheries residence. Note the displacement of stone blocks along the top of the sea wall. (Baker)

Below: Looking towards the old "Cayadetta" wharf and the M.B.L. Club. The Penzance Garage may be seen in the distance. In the upper left hand corner is the Old Stone Building, where water jumbled cannikins of specimens prepared for shipment by James McInnis and his staff. (Baker)

centers, and New York is not officially designated as a forecast center.

Observations of upper winds from stations adjacent to the coast were almost entirely lacking that morning, due to the heavy rain that was falling over a wide area. Only one such station was able to obtain an upper-wind observation. That station was Washington, D. C., and it showed that, although the winds were northerly in the lower levels, winds of 40 to 50 miles per hour were blowing from the south and south-southwest between 3 and 5 kilometers above the surface. It would seem to be an inescapable conclusion that these southerly winds were part of the vast anticyclonic drift aloft on the western margin of the Atlantic "HIGH". Since the position of the vortex was only about 300 miles south-southeast of Washington at this time, the logical supposition would be that its movement was being governed by winds of similar character. A forecast based on this observation would certainly have predicted an almost straight northerly path from Hatteras, a path which would cross Long Island, and which would give rise to southerly winds of hurricane force plus a storm wave along the coast to the east of the vortex center. The fact that this important observation was overlooked is puzzling in itself, but perhaps the most amazing aspect of the whole affair is that the official forecaster on duty at Washington on Wednesday, September 21st, was none other than the man who formulated the relationship between the movement of tropical cyclones and the wind direction at 3 to 5 kilometers above the surface!

Now it is all very well to review an event of this sort after it has happened. It is then easy in the light of retrospect to see the mistakes of others, because plenty of time is available for careful analysis. In all fairness, therefore, the writer wishes to state that the individual who made this seemingly inexcusable error of judgment is beyond all doubt the best forecaster at the Washington forecast center, if not the best in the entire Weather Bureau. How can his disastrous failure to make a timely and correct diagnosis be accounted for?

To the writer, at least, the explanation is crystal clear. Under existing Weather Bureau regulations the forecaster in Washington must finish the preparation of his morning forecasts not later than 9:45 A. M. Now, the morning reports of surface weather conditions from all over North America do not commence to come in until 7:30 A. M., and it is about 9:00 A. M. before the plotting of all these data on the weather map has been completed. This allows the forecaster approximately 45 minutes in which to analyze the surface chart

(really a one-hour job in itself, if carried out painstakingly), perform computations and prepare the weather forecasts for a dozen different states. Obviously, no man can do a proper job of forecasting under these conditions. If, on the fatal day of September 21st, the official forecaster had had until 10:15, or even 10:00, in which to make his final decision, it is almost certain he would have arrived at a different conclusion. And everyone will agree that a hurricane warning sent out at 10:00 A. M. would have constituted a greater service to the public than an ordinary gale warning sent out one hour earlier than that.

The official forecasters are not to be blamed for the regulations. They, more than anyone else, realize the desirability of ample time for the preparation of a forecast. But under the existing set-up in the Weather Bureau they are obliged to adhere to the schedules decided upon by the chief of the Forecast Division. The latter, in turn, is influenced by the demands of various commercial interests and of the newspapers.

It is an unfortunate fact that past policies of the Forecast Division of the Weather Bureau have led to the sacrifice of scientific practices in forecasting for the sake of speed in turning out vaguely-worded forecasts which ordinarily will "get by." A far more wholesome situation would now exist if outside demands for "rush" forecasts could have been resisted in the name of science. As it is, there is no great enthusiasm towards the development or use of exact and truly scientific methods because there is not time to apply them properly.

In the last analysis, then, it is the public that is to blame for unfortunate events like those of Wednesday, September 21st. No civil service organization, such as the Weather Bureau, can be expected to stand up and tell the people what is best for them. It merely gives service of a character which is just sufficient to keep the public satisfied and to make a case for a "whitewash" in the event of a serious failure. If the people want a better government weather forecasting service they must demand it forcefully, but they also must realize that greater speed in the preparation and issuance of weather forecasts is not as desirable as the attainment of greater accuracy through slower and more painstaking methods.

What appears to have been regarded as one of the more minor catastrophes of the hurricane was the destruction of the Block Island fishing fleet. In Norway, if a fishing fleet is lost because of inadequate storm warnings, there is a tremendous public clamor. That is one reason why Norway has developed one of the best government weather forecasting services in the world.

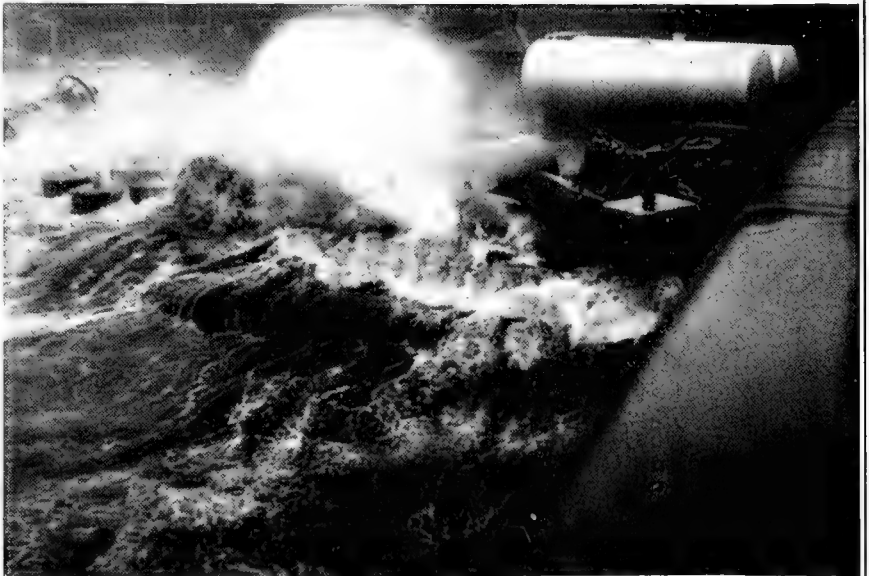


GAS BUOYS

Set afloat by the storm wave at the U. S. Light-house Bureau station at Little Harbor.

MOORING BLOCKS

of cement tossing in the waves. Each weighs about a quarter ton. These photographs were taken by Quartermaster W. S. Smith of Light-ship "Anemone."



AT REST

Buoys swept from the yard during the storm. The buildings are the Robinson house and garage, both visible in the upper left hand corner of top picture on this page.

THIS HURRICANE AND OTHERS

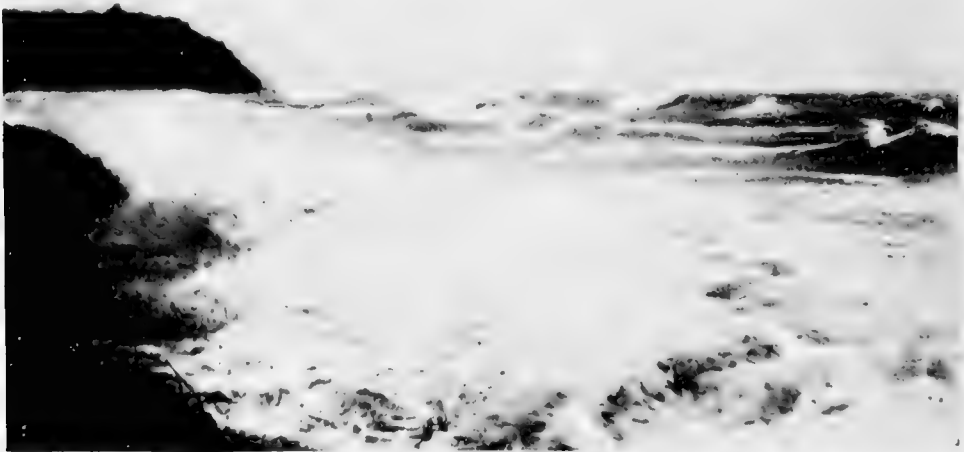
DR. ALFRED C. REDFIELD

*Professor of Physiology, Harvard University;
Senior Biologist, Woods Hole Oceanographic Institution*

I had no particularly exciting adventures during the storm of September 21. My work at the Laboratory came to an end for the summer when the electric current went off at about four o'clock in the afternoon. The harbor was then rougher than I had ever seen it, with waves breaking over Grassy Island and the sea wall at the Bureau of Fisheries, so I went home to get my camera. It was blowing so hard I felt there was some danger from falling trees and wires, and my daughter, on being cautioned, remarked that she had just noticed that the ground was coming up under her feet when she passed a tree. The tide was then unusually high in the Eel Pond, having flooded the Goffins' lawn, and a heavy sea was running. I made photographs of Great Harbor, where several of the schooners were dragging their anchors and pitching heavily, and saw that the waves were washing over the Yacht Club pier and that people were at work taking care of the rowboats. By the time I got back to the Oceanographic, the tide was nearly up to the top of the wharf, and we realized that the *Atlantis* was in grave danger of pulling up the piles, to which it had been lashed with many heavy hawsers. The seas were then breaking heavily against the under side of the wharf, and it looked as though the whole thing might go. The *Asterias* and the *Risk* had been brought into the enclosure behind the dock, where they were well sheltered by the *Atlantis*. The rowboats had all been carried up into

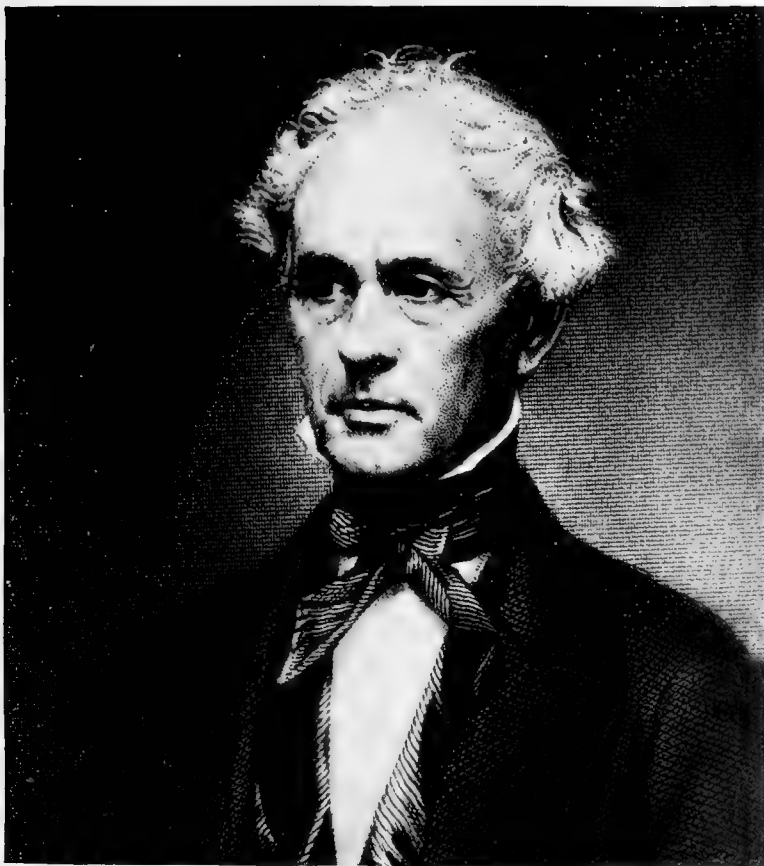
the back yard, and men were at work securing the gangplank to the float.

While we watched, the tide gradually came up over the wharf behind the Penzance Garage and demolished the shed which stood there. At about this time it was discovered that the water was coming into the basement of the Oceanographic building through the flooring drains and the plumbing system, and I busied myself helping Mr. Schroeder to block up those various inlets. In this way we prevented the water's rising in the basement to more than about eight inches, until we discovered that it had come to the level of the door sills and was beginning to leak in. The serious question in my mind was whether the tide would begin to go down at high water or whether it would continue to rise for some hours afterwards. We now noticed that the water was beginning to run out across the lawn toward the harbor, and thought that this indicated the falling of the tide, but when we saw the turbulence of the current which was flowing through the street and out of the Eel Pond, we realized that it must mean that water was coming over from Buzzards Bay. We went up into the cupola, climbed out of a window, crawled out on our hands and knees, and got into the lee of the cupola, from where we could see clearly the extent of the flood. It was evident that water was coming across from the Bay in at least two places along Millfield Street and that my house and the Catholic church stood



SURF AT WOODS HOLE NEAR NOBSKA LIGHT

Two hours before the storm reached its maximum intensity.



WILLIAM C. REDFIELD

First to discover the whirlwind character of the hurricane. Redfield was also the first president of the American Association for the Advancement of Science.

on an island still above water. There seemed to be a definite tide-rip where the water poured into the Eel Pond in front of "Do-ra-mi." I telephoned home and found that all was well and learned that several neighbors had been rescued from flooded houses. I was not, of course, aware of how serious the situation had become in that part of the town, and since there appeared to be great difficulty in going home, I stayed in the Laboratory. A little later, after it had let up and when it had also become dark, I went out into the street to see whether I could get home. The water was then well over my knees in the middle of the Main Street, and when I felt how strongly the current was running out between the buildings and could dimly see that there was much more turbulence in the direction of the drawbridge, I decided to turn back, a wise decision in view of the washout which was revealed when the tide went down.

At about eight o'clock things had let up considerably and it had begun to dry off, so I went

home, this time going around by way of West Street. The water was now down to normal level in the Eel Pond, and as we passed the rear of the M. B. L. we encountered a very considerable stream of water flowing out from the basement. At the corner of Millfield and West Streets there was still about two feet of water in the street. As we waded along, I heard a loud meowing, and, on casting about with my flashlight, discovered a very unhappy-looking cat sitting on Miss Tinkham's roof, crying its heart out. When I got home I found the family sitting around a candle and comforting a refugee, who had been brought in from a flooded house and was worrying only about the fate of her cat, which had been left with a newly arrived litter of kittens.

I was not impressed at any time with the extraordinary force of the wind and do not think that it actually blew harder than I had seen it at Cuttyhunk in a hurricane, which had passed south of Nantucket several years ago. In that instance more things had seemed to be picked up and



HIGH WATER ON WATER STREET

(cont. on next page)

blown about, but as I had been on a boat anchored in the harbor at the time, I might have arrived at an exaggerated notion of the severity of that storm. The serious character of this storm was due to the fact that the storm center passed to the west of us so that we got a southerly wind, which blew directly into the Woods Hole harbor. This, coupled with the coincidence of the storm and the high water, caused the unusual damage about the harbor front. It was very evident, on driving to Boston the following day, that the wind had been much more severe to the north and west and had done much more direct damage to trees and buildings. The flooding from Buzzards Bay was, of course, the peculiarly treacherous quality of this storm, an occurrence which, I imagine, no one had anticipated. It seems to me probable that this was due not so much to the effect of the so-called tidal wave, which was heaped up by the storm as it advanced, but rather to the backwash of water held against the northwestern shore of Buzzards Bay by the southwesterly wind when, on the shift of wind toward the west, which occurred as the storm center passed, the forces holding this water disappeared and permitted it to slosh back against the opposite side of Buzzards Bay. I am quite certain that water did not begin to flow out of the Eel Pond until the wind shift occurred. It would be extremely interesting to collect the observations regarding the time of the various events necessary to test this idea.

Although present residents of Woods Hole have no recollection of any similar catastrophe, Mr. Trayser, in a recent issue of the *Falmouth Enterprise*, records three previous occasions when hurricanes created tidal waves in Buzzards Bay: namely, in August 14 or 15th, 1635; September 23, 1815; and in 1869. The readers of THE COLLECTING NET may be interested when I draw on my family archives for an account of a similar storm which crossed New England in 1821 and which had a profound, and fortunately constructive, effect on the advancement of knowledge about tropical hurricanes and on meteorology in general.

My grandfather records, in his "Recollections", that on the evening of September 3, 1821, while his stepmother was lying on her deathbed, a gale, short in duration but terrific in violence, passed over Connecticut. For many years thereafter it was spoken of as the "Great September Gale." About a month after this, his father, William C.

Redfield, visited Stockbridge to carry to his wife's parents some of her belongings and to give the sad history of their daughter's last illness. The journey of seventy miles between Cromwell, Connecticut, and Stockbridge was made by wagon and occupied two days. As he drove along, he observed that at Middletown and Cromwell the wind had been from the southeast and the trees lay prostrate with their heads northwest. On reaching Berkshire he was surprised to see that they lay in the opposite direction, and on conversing with the residents of that region, he was astonished to learn that the wind, which at 9 P. M. had been from the southeast at Cromwell, had been in Stockbridge from the northwest at precisely the same hour. These facts at first seemed to him irreconcilable. It did not appear to him possible that two winds of such violence should be blowing directly against each other at the distance of only seventy miles. The only explanation of this paradoxical phenomenon was one which he was then led to accept hypothetically, but which he afterwards confirmed by years of observation and the collection of innumerable facts and which established the circular movement of the wind in great storms. The *American Journal of Science and Arts* of April, 1831, published the detailed record of the course of the Great September Gale of 1821, based on reports obtained from at least forty places, including ten ships at sea. The earliest trace of the hurricane was from off Turk's Head in the West Indies. The storm crossed over the continental coast south of Cape Hatteras and veered to the northeast, following the coastline closely, its center apparently passing across the mouth of Delaware Bay and hitting the New England coast in the neighborhood of Bridgeport. It passed across the Connecticut Valley and was last observed in northeastern Massachusetts. In New York, at the time of low water, the wharves were overflowed, the water having risen 13 feet in one hour. At Boston the gale commenced at 10 P. M. but does not appear to have been severe. At the time the storm was raging with its greatest fury in New York, the citizens of Boston were witnessing the ascent of a balloon, and the aeronaut met with little or no wind.

Similar records obtained following two severe northeast storms, which were felt in New York City in 1830, showed them to have a similar course and character, though they followed the

Above: Waves crashing against the sea wall across the road from the house occupied by Dr. S. E. Pond and his family. Taken from the corner of the M.B.L. Building. (L. von Bertalanffy)

Below: The sea sweeping over the land in front of the M.B.L. The Woods Hole Oceanographic ketch, "Atlantis", is in the background. This photograph was taken before the height of the storm; the pier of the Oceanographic Institute visible in front of the vessel later was completely submerged.

(L. von Bertalanffy)

more usual route to the south of New England's coast, and led to the first published account of the cyclonic nature of such hurricanes and the plotting of their courses and rates of progression. These studies were continued and amplified by observations of Reid at Bermuda and Piddington and Thom in the Indian Ocean and not only led to

the establishment of definite rules for handling vessels on the approach of a hurricane, rules which still appear on the pilot charts, but also laid the basis for the understanding of the cyclonic disturbances which characterize the weather in temperate latitudes and for the synoptic method for analyzing the movements of air masses.

EFFECT OF THE HURRICANE UPON THE MARINE BIOLOGICAL LABORATORY

DR. CHARLES PACKARD

Assistant Director, The Marine Biological Laboratory

We are gradually recovering from the effects of the storm of September 21, profoundly grateful that no one of our number lost his life. Many took great risks in the line of duty and more than once were in danger of being swept away in the rushing waters. Our sympathies go out to those families who have sustained losses by tragic death and to those whose possessions were destroyed. It is hard to believe that in the short time during which the storm and tide were at their height, so much devastation could occur.

The damage to the Laboratory is largely due to the water which filled the halls and rooms in the basement of the Brick Building to a depth of four feet. The flood entered suddenly. Attempts to keep it out by bracing the doors were rendered useless when the windows in the basement of the Library burst under the great pressure. Water poured into the Apparatus room, submerging microscopes, electrical apparatus, and a great quantity of other valuable equipment. It covered the storage battery, thus cutting off the current which was thought to be a sure source of light and power if ever the town supply failed. It submerged a portion of the switchboard, and rushed into the Chemical Room, tossing bottles and glassware about. Fortunately the containers of strong acids and alkalis did not break. The water came in through the doors and windows of the Supply Department, in an instant creating the utmost confusion. It rushed waist deep around the Stone House, excavating a great hole underneath the Club House, and tearing loose most of its supports. Finally, the flood bore the Bath House across the tennis courts, and deposited its eastern end on Dr. Howe's lawn.

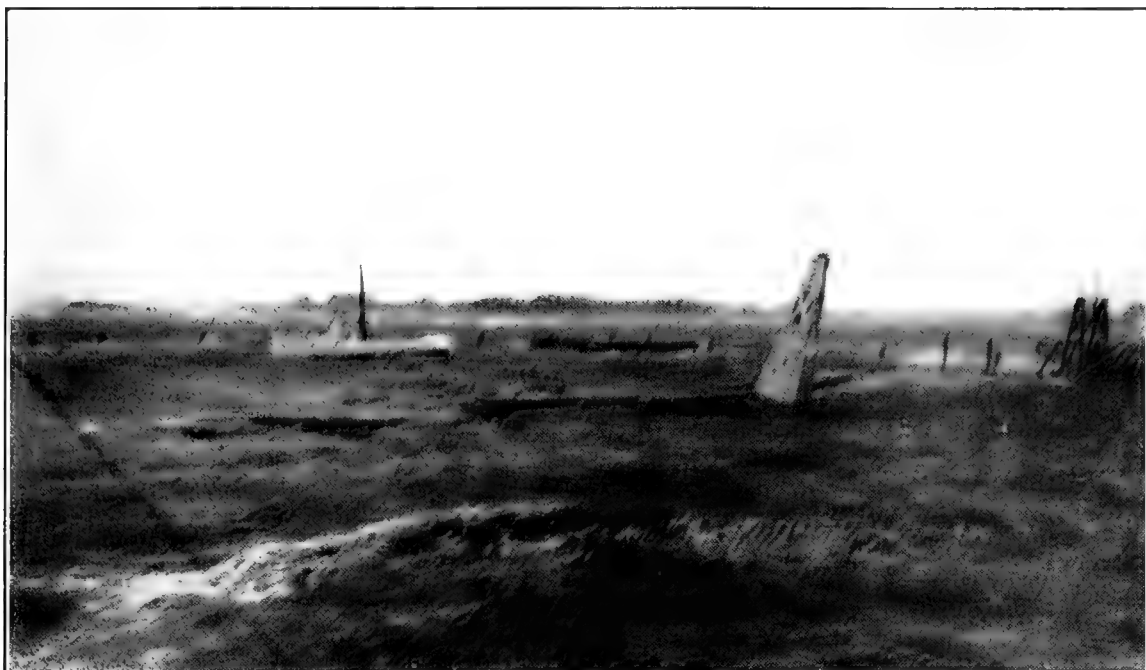
During the storm the Laboratory force worked valiantly to save essential equipment. Mr. McInnis and his crew struggled with the boats, and succeeded in keeping the *Nereis* afloat and sound. The two small boats capsized when the flood abated, but were recovered without serious damage. Mr. Larkin and his men formed a bucket brigade to scoop water from the Pump House and

succeeded in saving the elaborate machinery. Dr. Pond and Mr. Boss moved some of the apparatus from the floor to tables, but the sudden inrush of water ended their labors abruptly. Mr. MacNaught opened the Apartment House to those who had escaped from their houses on Penzance and elsewhere, arranged for a plentiful supply of hot coffee at the Mess, and quieted the fears of those who found themselves unable to communicate with their friends. All their activities were carried on in darkness. No electricity was available; flashlights, oil lamps, and candles had to suffice.

The next day, mild and clear, saw everyone beginning to repair the damage. The Fire Department pumped water out of the Brick Building, and men wielded pushers and brooms, scraping and sweeping out the silt which covered the floors. The water-soaked apparatus and records were carried upstairs under the direction of Dr. Pond. The capsized boats were hauled out and their engines taken down. Since then the work has gone on all day and far into the night. Much of the scientific equipment has been cleaned and oiled; the motors have been baked in the Mess boiler room and replaced; the storage battery has been drained and cleaned. The Chemical Room is gradually being restored to order, and the Laboratory begins to assume a more normal aspect.

We are profoundly grateful to Dr. Pond, Mr. McInnis, Mr. Larkin, and Mr. MacNaught and to all those who worked with them for their immediate and loyal response during this disaster. Their efforts resulted in reducing materially the loss which would have been sustained if any delay had occurred.

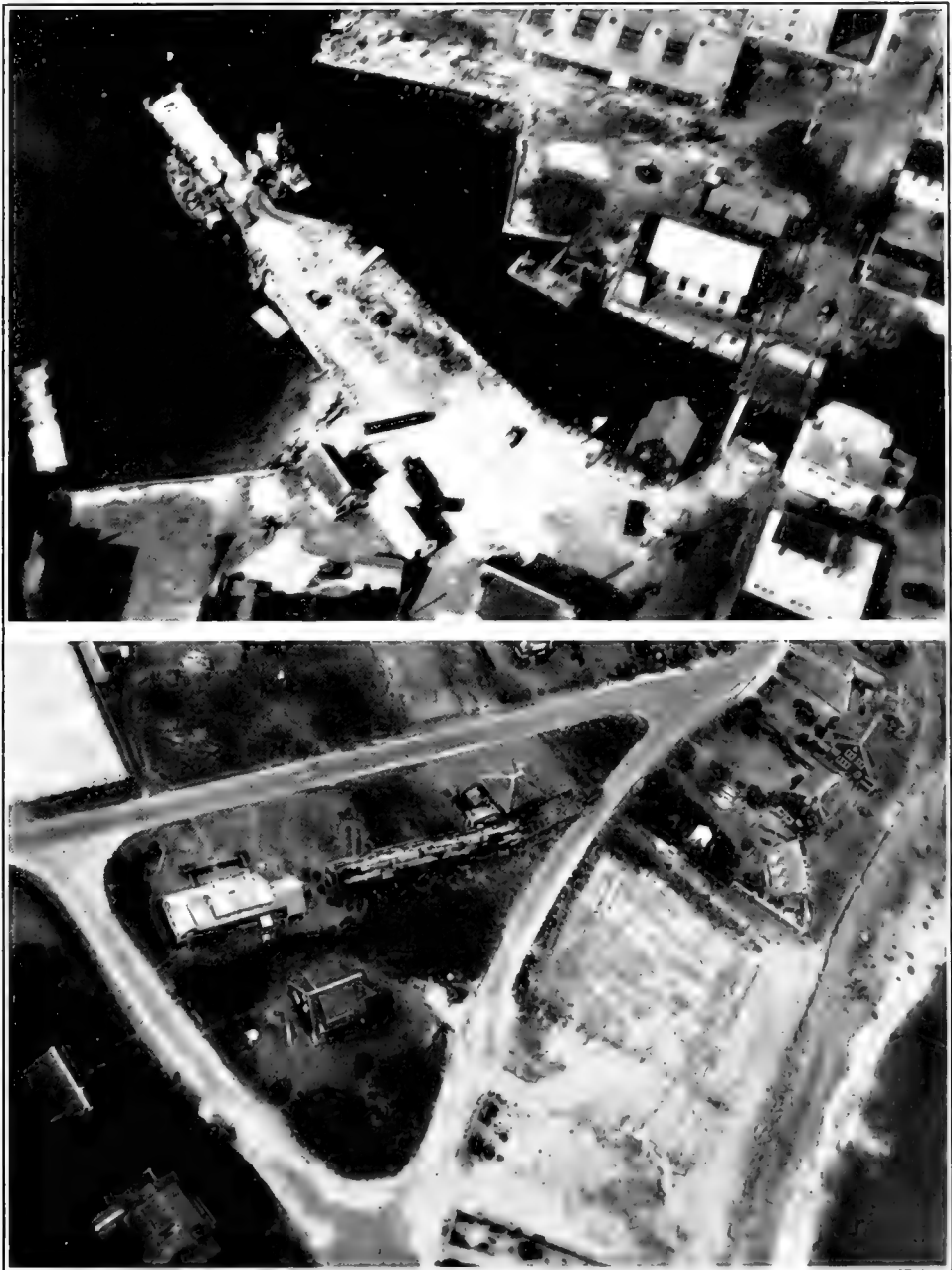
At this time it is not possible to give a reliable estimate of the cost of repairing the damage. A total of \$25,000.00 has been mentioned in the newspapers, but this may be too large. The Laboratory will make every effort to restore everything that has been damaged to its normal condition. It looks forward with confidence to a successful season in 1939.



THE RAGING WATERS AT THE U. S. BUREAU OF FISHERIES STATION

Above: Photograph of the pier showing the range light, supported by planking from the pier, being carried across the lagoon. (Copyright, L. A. Baker).

Below: Scene about the laboratory as the height of the storm approached. (Copyright, L. A. Baker).



DRAW BRIDGE AND BREAKWATER BEACH FROM THE AIR

Above: Aerial view of Dyer's Dock and the entrance to Eel pond after the storm. All the land shown in this view was inundated. In the lower right corner may be seen the temporary wooden passageway erected at the drawbridge. (Ware Cattell).

Below: Aerial view of the Breakwater beach. The bathhouse is visible in the upper center, where it had been carried from its position on the beach at the lower right. (Ware Cattell).

THE HURRICANE AND ITS EFFECT ON THE WOODS HOLE OCEANOGRAPHIC INSTITUTION

COLUMBUS ISELIN

*Physical Oceanographer, Woods Hole Oceanographic Institution;
Assistant Professor of Physical Oceanography, Harvard University*

The recent hurricane was extremely kind to the Woods Hole Oceanographic Institution. No one was hurt and the property damage did not amount to more than five hundred dollars. Our seawall and pier being new and strong, the water could do little more than shift the dirt and cinders of the drive-way. A few stones in the wall were also displaced slightly, and the top of two piles on the outside of the pier were broken off. The cellar of the building was flooded, but only to a depth of about 18 inches.

The *Atlantis* came in to Woods Hole early on the day of the storm. Captain McMurray of course knew the hurricane was behind him and, therefore, let go an anchor as he came in to the pier. This anchor played a large part later in the day in holding the ship off the pier. About half past ten in the morning it became clear to those of us who are weather minded that the hurricane was approaching. The wind was fresh southerly and typical, high hurricane clouds could be seen through gaps in the high fog resulting from the passage of moisture laden air over the Vineyard. About noon the barometer began to drop rapidly and the wind increased. Of course, we had no idea how large the low pressure area was and how close the center would come. The fact that the wind remained southerly indicated that the center of the storm was passing to the west of Woods Hole.

About two-thirty a heavy swell came into Woods Hole harbor and the *Atlantis* began to ride up and down against the piling of the pier. Some extra lines were rigged, and the small boats made secure behind the wharf. Since the sailors had been standing watch during the previous night, they were given the rest of the day off, as soon as the sails were furled and the decks washed down. Thus in the early afternoon the ship was very short handed and the Captain began to worry about finding his crew. However, as the wind increased the men began to return of their own accord and by three-thirty all hands were at work. The row boats were taken out of the water and carried up to the grass near the main building. Extra hawsers were brought up on deck and chafing gear rigged on the lines leading to the wharf.

Soon the swell in the harbor was flattened out by the increasing wind and the *Atlantis*, therefore, became steadier. However, the tide also rose rapidly so that the waves began to break over the deck of the pier. At this point, about four o'clock,

an eight inch hawser was rigged fore and aft to the corner piling and then hove taut on the windlass. Before this was finished the men on the pier were up to their knees in water.

High tide in Woods Hole harbor was scheduled to come at about seven o'clock. The barometer reached its lowest point (29.32) at about five o'clock and the wind then shifted to the southwest so that Nonamesset gave some lee to the eastern side of the harbor. At the height of the storm the water-line of the *Atlantis* was about one foot above the cap-log on the pier. If the tide had risen another foot, she would have come in over the edge of the wharf and considerable damage would have resulted.

Meanwhile, the crew and the men from the laboratory were all busy with the various boats. The row-boats were causing considerable trouble, for they kept blowing about on the lawn. All of us were unconscious that anything else was happening to Woods Hole, especially as none of us thought of the possibility that sea level in Buzzards Bay might have risen more than in Woods Hole. Thus when the rush of water came across the main street from the Eel Pond, it took us some time to realize the significance and by the time we did, it was too late to send men and boats to the back of the town.

The rush of water from the Eel Pond passed both sides of the laboratory building, breaking down the wall in the narrow gap between our building and the M. B. L. Club. It also made it impossible to walk between the *Atlantis* and the main building. Thus while the flood continued our men were either indoors or on the ship. The current also pushed the *Atlantis* away from the pier and lessened the danger of her breaking off the tops of the piles against which the wind was forcing her. Due to our concentration on our own problems, when the time came that we could have been of help to the people along Millfield Street, we were not able to get there. There was nothing to do but observe the storm.

Several of us climbed up to the cupola on the roof of the laboratory building and looked out towards the north and east. It was at once clear that Buzzards Bay was at least eight feet higher than Vineyard Sound and that this was the source of much of the water sweeping across Main Street. We also for the first time realized the full extent of the damage to the town and to the water-front.

As it grew dark, the tide dropped rapidly and the wind gradually diminished. At its worst, the wind had probably not been over 65 miles per hour. The great majority of the damage came from the tide. No tidal wave was observed at Woods Hole. The extreme rise (7 feet above normal) resulted from the frictional effect of the wind and the fact that the height of the storm coincided roughly with the time of high water.

During the night the wind continued from the southwest and a great deal of floating wreckage became wedged in between the *Atlantis* and the sea-wall. The ship proceeded to grind up this lumber into small pieces, the paint being mostly scraped from her sides. Fortunately no rivets

were started. The noise made sleeping on board most difficult.

The only members of the staff who suffered considerable loss from the storm were Dr. and Mrs. Seiwel whose cottage was swept from its foundation and consequently most of their furniture and clothing were soaked.

The next morning the radio operator on the *Atlantis* did a rushing business sending off messages. It was not realized until the next day that many of these radio messages could not be delivered because the telephone wires were also down inland. Only when we heard that the center of the storm had struck the coast a hundred miles west of Woods Hole did we understand how extremely lucky we had been.

THE EFFECTS OF THE HURRICANE ON THE UNITED STATES BUREAU OF FISHERIES STATIONS

FRANK T. BELL

Commissioner, United States Bureau of Fisheries, Washington, D. C.

Since several of the Bureau's stations were in the line of the terrific hurricane which visited the New England States during the week of September

19, there is naturally much interest in the extent of the damage. Fortunately, no injury was suffered by any members of the personnel. The words of Superintendent Goffin of the Woods Hole, Mass., Station will give a vivid picture of the situation there:

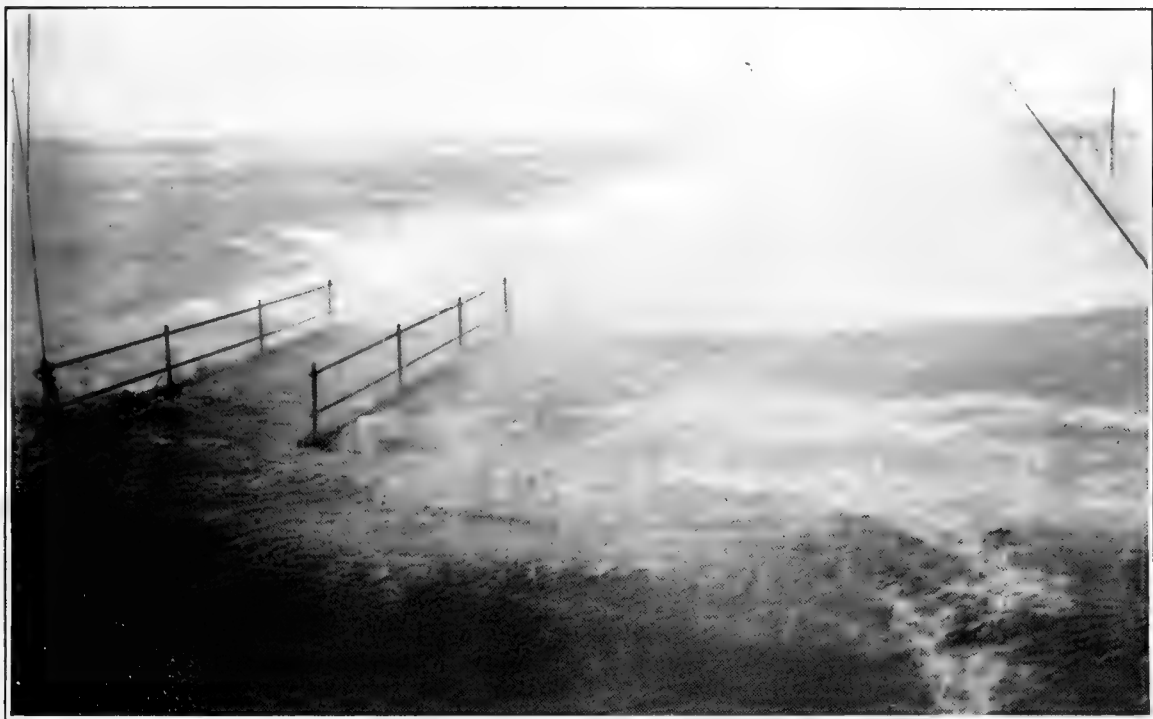
"You have probably been informed of my telegrams to the Commissioner relative to the hurricane and tidal wave which struck this village the afternoon and night of September 21. The wind and sea were terrific. The east dock and sea wall is practically gone, the coal dock, west dock, and south docks are badly damaged, and the cap stones of the sea wall have been knocked out. All basement windows and doors of the residence building are smashed; this basement had six feet of water, which has been pumped out by the local fire department. We were able to get up steam on the boiler and syphon out the hatchery building ourselves. Six of our pontoons are a total loss, having been swept out to sea. The sea entered the buildings through the front door and basement windows. The slate roofs of both the residence and the hatchery building are badly damaged *****. The fence along the street has been mostly carried away, and the grounds between the residence and sea wall are badly washed out. The boiler house had three feet of water, but this disappeared when the waters receded, leaving very little damage there; the basement of the residence building has a great deal of debris, seaweed and sand washed in from the sea. We are without lights and cannot cook until the gas company gets its mains in operation. I am happy to say that out of all this havoc our boat, the *Phalarope II*, was damaged but very little, so far as I can



U. S. PROPERTY IN WAKE OF HURRICANE

Above: Destruction wrought by the hurricane at the U. S. Bureau of Fisheries. One of the range lights swept from the pier stands at the left. (J. Silva).

Below: The Coast Guard dock, with wreck of the other range light. (J. Silva).



ANGRY WAVES LASH THE U. S. BUREAU OF FISHERIES PIER

sweeping away the harbor range light. The footbridge across the seal pool in the foreground was also carried away. The "Phalarope II", seen in the distance, was repeatedly swept on and off the pier. (Copyright, L. A. Baker)

now see. The salt-water suction pipe line where it lay along the wall is practically all destroyed. As it is now, the property and the *Phalarope II* are (due to the loss of the east-side sea wall) without protection against the winter storms."

The Nashua, N. H., Station was damaged by the uprooting of a number of trees which caused injury to buildings and damage to the ponds. It is estimated that the amount of \$15,000 will be necessary to rehabilitate this station.

Both the Gloucester, Mass., and the Boothbay Harbor, Maine, Stations escaped without any appreciable damage.

At the Pittsford, Vt., hatchery the creek overran the station grounds and flooded out the ponds. The brood stock was thoroughly mixed but seemed to have an affection for the home place, and comparatively few fish were lost. Mr. Lord, in charge at Pittsford, reports however that many wild trout were undoubtedly destroyed since

they were discovered stranded in numerous instances along the line of debris marking the high water. A bridge, the property of the Bureau, was washed out but inasmuch as this structure was to be razed within the next few days for replacement, the storm must be credited for this contribution.

At the time of writing, no detailed report was received from the new station at Arcadia, R. I. Since there had been but little progress in the construction of this station there could be little damage to buildings or other property.

The oyster laboratory at Milford, Conn., escaped damage, although the Yacht Club building located next to the station was demolished and a large number of elm trees surrounding the station and along the street leading to it were blown down. The station grounds were from one to three feet under water, but all the equipment and material had been placed on higher shelves or otherwise made secure.

DAMAGES CAUSED BY THE HURRICANE TO THE U. S. FISHERIES LABORATORY

DR. PAUL S. GALTSOFF *Acting Director*

Fisheries grounds littered with debris, boats, oars, seaweeds and silt present probably the most convincing picture of the ferocity of the tidal waves and wind that struck Woods Hole. The

fury of the lashing seas which wrought this terrific destruction was vividly described by Robert A. Goffin, Station Superintendent, who was on the job throughout the storm.



The most serious destruction was done to the pier, three-quarters of which was carried away and deposited on the grounds nearby. Not only the wooden upper structures and planks were demolished, but the heavy stones forming the wall were lifted, turned over and tossed away. The pier was built many years ago as a protection for fisheries boats and a harbor refuge for small private crafts. In the past it was damaged several times by storms and ice but its foundation remained firm and strong until this year's hurricane scattered it as if it were a pile of pebbles. Familiar to everybody at Woods Hole, range lights mounted on the two sides of the pier and a small oil house near the laboratory were carried away and deposited on the Coast Guard grounds. The landing dock, protected by the sea walls, was completely demolished.

Water which filled the basements of the laboratory building and of the residence undermined

the foundation, smashed the windows and considerably damaged materials and equipment stored there. Tile roofs of both buildings were ripped leaving several large holes, some of them about 10 feet square. All railings and fences were demolished and part of the sea wall along the small beach badly damaged.

The swinging bridge over the entrance to the pool was twisted and bent, suction pipe for sea water supply was completely destroyed. No serious damage was done, however, to the pumps and machine shop.

Fortunately the laboratory boats and scientific equipment was not damaged. It is difficult at present to estimate with accuracy the cost of repairs and replacements. It seems, however, probable that not less than \$100,000 will be required to put the station back in its working condition.

DAMAGE TO THE MARINE BIOLOGICAL LABORATORY PROPERTY BY THE HURRICANE AND FLOOD

T. E. LARKIN *Superintendent*

Only those of us who were in the flood and saw its terrible results can visualize the extreme power and force of the sea when it goes on such a rampage as that of September 21.

Water was rising inches by the minute, and we could only say, "Well, it cannot come much higher," but higher it came at its sickening speed.

Our doors and windows in the basement were like paper sheets trying to hold back the deluge. They were not of much use against the pressure of water four feet deep outside. We could do nothing but vacate the basement in a hurry.

The main switch-board room we barricaded up two feet, but what is two feet when four feet pours in on us!

There were, at one time, five feet of water in our switch-board room, and what a licking our Buck & Boost set took along with all our switches, controls, and fuses!

The battery next door also had the same dose, six inches to a foot over it, and what a distasteful job in the few days following was removing the ruined electrolyte and replacing with fresh water doses!

At six o'clock the onrushing deluge was entering the building through many channels. Since we had to keep the flood below our high tension transformers and cables, since this plant is the heart of the whole M. B. L., a young army of us formed a bucket brigade.

Work we did, two sections of men and boys passing the buckets, one to another, for about two long hours, and we are most thankful to all who dug in and saved all the expensive and important equipment. There was not over six inches of sea water covering the floor at any time.

The machine shop had its toll in damage, as can be seen. Many motors were under four feet of water and mud, drawers of fine tools were submerged under salt water and silt, and much electric stock took a bath.

The carpenter shop also had its visit, with the result of some small damage to motors and wiring.

Many windows were broken out by the heavy wind, flying shingles, and debris of many sorts. Even boarding and shingles on some of the old buildings went soaring off with the heavy, south-east wind. Our Club House took a whale of a

Above: Aerial view of the Bureau of Fisheries pier, showing what was left of the east side of the dock, the large stone blocks composing it having been washed away. The range lights shown washing away on page 15 and after the storm on page 18 were located about two-thirds of the way down the longer sides of the pier. (Ware Cattell).

Below: Aerial view of Nobska Point, showing washouts in the highway and beaches. Note the blocking-off of the road near the circle to prevent cars from tumbling into the washout shown in the upper right corner. The terrific power of the waves is shown by the fact that previous to the storm the shoreline to the right of the photograph was similar to the shore further left, being composed of boulders which made it impossible to approach the land by boat. There is now a sandy beach there, with only occasional boulders. (Ware Cattell).



DURING AND AFTER THE STORM

First row (down): (1) Foundation of the Marine Biological Laboratory Club House undermined by the storm. (2) The east side of the Club House; the force of the waves is indicated by the dislodgment of the stone blocks. **Second row (down):** (1) Mr. Albert H. Swain and Miss Nan Lewis on the Nobska Beach raft attempting to secure it to a telephone pole. The Nobska bathhouse was swept into the pond a few minutes later, followed by the car to the right. (2) The gangway constructed at the Eel Pond drawbridge for foot passage after the bridge had been damaged in the storm. **Third row (down):** (1) The Western Union garage which left by water and couldn't go home. The houses on Depot Avenue were so close together that it could not be taken back between them to its site on the shore. The garage is being towed to its new location on the main road to Falmouth. (2) The garage as it was being taken down West Street. (Six photos by W. Cattell). **Bottom row:** (1) Great Harbor at 4:45 P. M. Dr. Jewett's yacht "Marilyn" is in the center of the picture, with Devil's Foot Island behind it. Soon after this picture was taken, the boat was washed ashore on Penzance Point. (A. Redfield). (2) Boats being tossed by the gale in the Eel Pond at 4:30 P. M. (A. Redfield).

beating. First from the harbor side the hurricane and mountainous seas pounded against it, waves at times breaking over the roof. Then, as old Neptune went into reverse, the torrents poured over lots and roads from the Bay, washing much

of the soil from under the building, and carrying away many of its piers.

The Old Bath House went on a spree, and crossed over the new M. B. L. tennis club court. The high fence of the court wandered, one end re-

posing in the Harrison Howe back yard, the other end wrapping around the Bowman cottage, all still intact, a most unbelievable feat. The Sun Dial stood up like a major, taking its bath without a whimper. But what a sorry sight the new hedge, walks, and lawn were left in! All these sore spots will soon have their wounds dressed and repaired, for our Woods Hole must look like itself by next summer.

SPECIAL APPARATUS PROBLEMS ACCENTUATED BY THE STORM OF SEPTEMBER 21, 1938

DR. SAMUEL E. POND

Technical Manager

What an extremely rapid rise of water from the Eel Pond can do to scientific equipment is demonstrable in the Brick Lab, and our "disaster" has not even now, after two weeks of activity, been measured. Few, besides those who experienced the submersion, could capably describe the rapidity of change in our "apparatus" and "chemical" rooms or the dismal appearance of the laboratory equipment! Even as this is written, we who went through the exciting hours between 6 and 8 p. m. of September 21, 1938, are quite unable to tell a coherent tale of the tragedy. Things moved so fast that we who sought to barricade the outside doors and valiantly lifted drawers of supplies and heavy apparatus above knee-high levels were "flabbergasted" by the onrush of muddy water. Windows crashed about us as the panes of glass were overcome by the whirling tide outside our quarters. Then we knew we were at the mercy of wind and tide. From then on, as we saw the waters rise to a level which would attack the central storage batteries, and we knew chlorine gas was the ultimate answer, we began to migrate. At the same time the cry came through the corridors for a bucket brigade to bail out and save the power machinery and transformers. Long into the night willing hands forgot the laboratory equipment in their efforts to keep the sea-water pumping-motors and rotary converter dry, for we had no lights except battery lamps to occasionally find water-depth or footing.

Once or twice, in respite, as some of the crew migrated to the Mess Hall to dry off, and hover around the ranges for a sip of hot coffee, we would hear of a soul or two who had penetrated the darkness of the chemical room to see what might be done to save further damage. After the excitement had died down, Jay Smith admitted he had meandered through the surging bottles of the chemical room but had really been unable to do anything in waist-high waters. When the waters had receded sufficiently out of doors it was necessary to work in groups of three or four

We are now very busy in all the buildings and shops reclaiming motors, machinery, and stock used in such equipment; and what a task it is! But we are making great progress, and much of our equipment is coming through in good shape. So we have much to be thankful for after all, as no lives were lost nor was serious injury done to any one about the plant.

to force open the well-swollen and barricaded doors so that the corridors might drain of water. Those with boots on were the only ones who fared well in the outward rush. Robert Liljestrand and I were caught in the stream quite unprotected, as we tried to save the xylol barrel and benzol bottles from emptying into the receding waters, after which we had to dry off again and get rid of the irritants on our feet and shins. Only as daylight approached did we really see the jumble in what had been the "chemical room". Bottles were everywhere, mingled with moist chambers which had floated far from their normal stations and landed among finger bowls. Only the ironware had stayed put, and such a foul mess it all looked with salt and agar piled in every recess! Fortunate was the Laboratory to have had the recent return and the "late-season-visit" of our old friend "Bob" Liljestrand, who was then and there impressed into his former position of guardian of the night and who for days afterward patrolled the perilous corridors through pitch darkness while we were without electricity.

The submersion of research apparatus in the "bowels" of our laboratory building and the mixing up of chemicals and general equipment represent a heavy loss to the M. B. L. Much of the material has not only to be thoroughly rid of salt and mud but also dried and freed of corrosion. All that could be reached early was cleaned roughly and immersed in penetrating oil, which now is being removed so that we may more accurately assay our loss. Such a treatment of microscope lenses and movable parts of technical equipment will require weeks of patient manipulation.

Much of the damage is confined to equipment and materials which had been returned to the usual places of storage or to the machine shop for repairs and overhauling. This includes our electrical measuring instruments, such as voltmeters, potentiometers, standard cells, standard resistances, and adjustable shunts or rheostats; cen-



HIGH WATER AT WOODS HOLE

Above: The Supply Department at the Marine Biological Laboratory where the water rose to a height of four feet above the floor. (Baker).

Below: An oil truck, driven by John Handy, engaged in rescue work on Water Street. (Baker).

trifuges, chiefly the motors; thermostats, incubators and ovens; refrigerators and regulating equipment; autoclaves and sterilizers; respirimeters; microscopes, microtomes, and lenses; microscope lamps and illuminators; mechanical stages, gelatin (mounted) filters, substage darkfield condensers; special machines, such as grinders, shakers, and pumps; and electrical devices, including fittings, appliances, stoves, heaters, warming tables, and transformers.

Many of our friends will be interested to know that our microscope equipment was dissembled first with the help of Dr. Packard and a volunteer corps. This equipment is now being re-assembled by an experienced factory technician and tested to ascertain what portion must receive further attention, if any, by the makers. Because of the care with which the lenses particularly must be cleaned and reassembled, this is a tedious operation, occupying days, and there is much uncertainty as to final cost until the survey is concluded. Fortunately we were able to secure the prompt services of an experienced technician, from the Bausch & Lomb Optical Company, who had been located in the New England district for such technical work.

Uncertainty concerning the losses in the chemicals and general equipment has resolved into an assurance that the amount is not likely to be as large as first estimated. Few of the larger pieces of glassware were broken by the jostling, even though they were transplanted considerably and were obviously shuffled roughly. A large carboy of nitric acid was found unusually diluted, but nearly no trace of acid erosion was located. The dyes and drugs in a compact cupboard were all upset and askew, but by good fortune the stoppers were tight and there may not be a total loss even in those containers tossed about. Greater losses are expected in the stock chemicals in larger bottles, which were tumbled about, amounting to about half of the residual supply. Where the stock was preserved by stoppers which were waxed, little damage is expected, but many screwed-on bakelite tops were found loosened, making the contents of doubtful value. Anticipated replacements on account of these damages are expected to cost in the neighborhood of \$1000, including the replaceable records, technical library, and stores of supplies used in the operations of the chemical room.

Damages to the heavier and more technical equipment are not unlikely to total less than has been estimated, although the figure is written into the temporary list of losses at \$15,000. This amount will be revised as soon as the cleaning and testing of equipment is concluded and when it is decided whether or not equal replacements will be made in quantity and quality.

A great handicap was caused from the outset by an embargo on freight movement out of New England, so that the only factory attention our equipment could receive promptly was in the vicinity of Boston by local truck deliveries. As a consequence, it has been necessary for the staff available to do more work locally than might otherwise have been economical. We have segregated all of our equipment, therefore, into groups preparatory to shipment, where necessary, at the first advantageous moment; but most complicated equipment is cleaned of salt and dirt and protected by oil. It is doubtful if any further damage to the equipment is caused by the delay.

Large quantities of chemical laboratory ware are still in cupboards and drawers throughout the "chemical" room unexamined, as we have been forced to open the old wooden cases and drawers slowly. Here lies a large volume of glassware, including a great many individual pieces awaiting cleaning. And to think that most of it was cleaned and put away just prior to the storm and flood!

Glory be to Noah who had only animals, two by two; we have beakers, dozens by dozens, and Stenders, hundreds by hundreds!

HURRICANE DAMAGE TO THE SUPPLY DEPARTMENT OF THE MARINE BIOLOGICAL LABORATORY

JAMES MCINNIS

Manager, Supply Department

Standing on the partially ruined float stage of the Marine Biological Laboratory Supply Department, I attempted to estimate the amount of damage done to this department by the few hours of hurricane.

The dock under my feet had its live cars opened by the tidal water allowing all our hard-found biological specimens to escape. It seems almost incomprehensible that all the days spent in careful and patient collecting, were wiped away in a moment of storm. I suppose that in a way we were fortunate that only our live stock was damaged and not all our preserved supplies. For, although the water was four feet high in the stone building, and a few of the barrels of equipment were up-ended, the rest escaped without any damage. From the turned-over barrels we were able to salvage all the stock unharmed. And now, except for the fine powdered silt over everything and the necessity for disinfecting, we have managed, by working night and day, to get some amount of organization out of the chaotic mess of barrels and ruined files. So that our main worry now is just getting alcohol and formaldehyde through from Boston.

The pile of kindling wood before me once was the boat house. But the *Tern* and the *Sagitta*, our two invaluable supply boats, escaped with but a thorough wetting. They were turned upside down by the fury of the storm and so drenched that their new motors have to be completely overhauled and reconditioned. The *Winifred*, the boat used by our classes in the summer, was washed on top of the dock at Hadley's harbor across from Woods Hole. And the *Nereis* had to be moved from its usual harbor in Eel Pond to another anchorage until the ruined Main Street bridge is replaced.

A point of interest to you who know the Laboratory and its surroundings well, is that Devil's Foot, the island directly across from our main building, is now two islands, and Pine Island has been completely obliterated. Both are places where we get a great deal of our shipping supplies. The shores of Naushon, another supply area, have been covered with sand. All these changes will make it doubly difficult to obtain our specimens.

Fortunately our expensive embryological material was safe on high shelves in our main building, which was unharmed except for a few feet of water and wall and floor damage. So all in all, we suffered just an approximate three hundred dollars worth of damage to our supplies alone.

The tragedy, of course was to have our Supply

Department so handicapped both by storm and disrupted train service at the height of the shipping season. However, I am glad to report now (September 26) that we are able to ship anything but living material. And in a few days to a week we will be able to meet that demand under our normal schedule.



DOCKS AND PIERS TAKE A LASHING

Top to bottom: (1) Damage to the "Cayadetta" pier in front of the Marine Biological Laboratory. The steamship "Naushon" visible in the distance. (W. B. Harrison). (2) The east side of the Bureau of Fisheries dock after the storm. (W. B. Harrison). (3) Dyer's dock as the water began to rise. (F. Grace).

THE EFFECT OF THE RECENT TIDAL WAVE ON THE GEORGE M. GRAY MUSEUM AT THE MARINE BIOLOGICAL LABORATORY

GEORGE M. GRAY

Curator Emeritus of the Museum

The water rose to the height of three feet, six and one-half inches in the Museum and the Supply Department Building. The large table-like flat top case of draws was floated off the floor carrying with it a six foot glass show case. This case was filled with various specimens, as the table floated the glass case slid off and came against a tier of shelving loaded with jars of preserved specimens. What was in the show case slid off the shelves in more or less of a heap, and when the water went down there was the whole thing wedged in between two tiers of shelves almost on a balance, and one glass jar held the show case from doing further damage. Strange to say, not a pane of glass in the show case was broken, although it had eight large ones.

The full jars stayed on most of the shelves, and where the tops of the jars were securely fastened little or no damage was done, and after wiping were practically as good as ever, but the labels on many jars came off. Some were as clean and good as when first put on the jars, others were so soiled that they were hardly legible. Some looked all right but on touching, off they dropped. Many labels will have to be replaced. Comparatively little glassware was broken, strange and surprising as it may seem. The greatest damage was to charts, life histories of insects, and single specimens of insects put up dry (originally) in Riker Mounts, also dry collections of insects, skins of animals and birds, habitats groups and similar exhibits. The draws in cabinets swelled

so that they cannot be opened and it will take some time for them to dry enough to be opened.

Books, botanical mounts, and anything of paper or of cloth was more or less damaged. We are happy to say that *some* of the more valuable groups were on shelves above the water. Nearly all the mounted birds were on the highest shelves, and while the greater number were water birds with webbed feet and had been used to swimming, not one of them took to the water or even got their feet wet, but kept high and dry, except one Great Blue Heron which had the water lapping around its feet, but he was long legged and could take it standing.

The worst feature was the dirty mud and silt which filtered in with the water, and it certainly was a very unpleasant job to clean up. But with it all we have very, very much for which to be thankful.

We prefer not giving at this time the loss in money value. We shall defer this until later when we get a fuller and better idea of what can be saved and reclaimed, and know definitely what is really loss. There will be a great deal of time and labor involved in restoring the damaged specimens to a presentable appearance, when it is possible to save them. It will be weeks before the Museum can be put in its former condition. The specimens preserved in jars and bottles suffered comparatively little, aside from the labor of cleaning them up.

FALMOUTH FIRE DEPARTMENT AND THE HURRICANE

(Continued from page 1)

Lt. McWhinnie, and Game Warden Waterhouse, proceeded to the rescue of Mr. Cassidy. The men did an excellent piece of work on this daring rescue. At 3:35 I ordered a siren call sounded for volunteers to organize rescue squads. This call was met with great response.

At about this time calls began coming in thick and fast from Woods Hole, Nobska, The Moors, Menauhant, Silver Beach, and Megansett. As long as there were telephone lines left the calls came in. At this time I dispatched messages to the Coast Guard Stations at Chatham, and Nauset, and to the Cape Cod Canal Station. They responded with crews and dories.

The telephone operators deserve much credit for the wonderful work which they did for us in putting through our calls, and at this time I would like to express my appreciation to them.

At 4:35 the Woods Hole and North Falmouth circuits were reported to be out, and a dangerous live wire was reported down on Palmer and Lake

View Avenue. At 5:12 it was reported at the Central Fire Station that the roof had blown off a house and that help was wanted. At 5:23 Captain George Ferris and Captain Ray Locke were ordered to the Wellsmere Inn, in Maravista, to rescue people marooned there in cars. At 5:40 a call came for aid at the Peterson Bath House on Surf Drive, where a man and woman were in distress. I sent Firemen Donnelly and Manchester and Officer E. Sparre. They rescued the man but could not reach the woman. At 6 o'clock it was reported that Mrs. Stackpole had been rescued at Scranton Avenue and sent to The Elm Arch Inn in the ambulance.

At 6:55 Louis Stevens, with a truck, a skiff, and men, was sent to Nobska for rescue work. At 6:57 it was reported that Ladder 2 from Woods Hole in charge of Leighton Peck rescued Mr. Albert H. Swain and Mr. Ware Cattell. At 7 o'clock a call for help with the boats came from Gardiner Road in Woods Hole from Mr. Ernst



WRECKAGE IN GREAT HARBOR AT THE ENTRANCE TO THE EEL POND

Note the damaged foundation of the drawbridge, and the wall of a frame building floating in the water in the right foreground. (Virginia Overy).

Rhomeling. At 7:10 a call for help from Silver Beach was answered by two crews from headquarters and one from North Falmouth with Captain John E. Overy in charge. At 7:15 it was reported that Mrs. Minot, Mrs. John Parker, and Mr. and Mrs. Sabens had been rescued, after having been marooned at the Minot place on Mill Road. At 7:30 it was reported that a crew had removed Mrs. Alis G. Miller to safety from her home in Old Silver Beach. At 7:30 a chimney fire was reported at the home of Russell Nickerson in Falmouth Heights. Ladder 1 responded to the call. At 7:30 a call came from Mrs. Espee in Davisville, where the family was marooned. A crew was sent to aid them.

At 7:42 a call came from Woods Hole for more help and boats. I sent two crews and the Nauset Coast Guard to help them. At 6:10 Engine 2 and Ladder 2 left the Woods Hole Fire Station for drier quarters on Gardiner Road. At 6:32 the Woods Hole drawbridge was reported out. At 6:40 a report came in of a broken main on Millfield Street, and we notified the Water Department. At 8:10 Herbert McLane and his crew were sent to Pine Island in West Falmouth on rescue work. At 8:11 a call for help came from Menauhant. I had this answered by two crews from East Falmouth. At 8:25 I sent Lt. Turner and two crews to Silver Beach. Later he reported

that four people had been washed away, two of them being Mr. and Mrs. Jack Jones of Dorchester (later found drowned). At 8:25 I sent Albert Irons and crews to people marooned near Menauhant Bridge, over Bourne Pond River.

About 8:30 the Bourne Bridge approaches were reported to be unsafe and Great Pond was reported impassable. At 8:43 I sent officers Waterhouse and Taylor to Megansett. At 8:47 Captain McInnis reported that those in charge at Woods Hole were inspecting every building on Main and Millfield Streets and had rescued all people from the buildings. At 8:50 it was reported that the Woods Hole fire engine had taken a station with its lights on the drawbridge, as Woods Hole was in total darkness. At 8:55 I sent the Hill boys to Falmouth Heights, where a house was reported to be in the harbor. They found that the house was in the harbor but was not occupied. At 8:56 I sent a crew to Black Beach in West Falmouth, where the Bowerman family had been reported to be missing (later all were found). At 9:05 North Falmouth Station reported tremendous loss in Silver Beach. Captain Albert Mullen, with two crews and the Chatham Coast Guard, responded to this call. At 9:19 a report came in to headquarters that Mr. and Mrs. Jack Jones and Carl Merrill of Silver Beach had been found drowned. At 9:30 the Rudd family was reported missing



SCENES OF LOSS OF LIFE AND HEAVY PROPERTY DAMAGE

Top row: (1) The washout on Bar Neck Road at the entrance to Penzance Point. It was here that three Coast Guardsmen, engaged in rescue work, and two other men, lost their lives. The Murray Crane residence is in the background. (A. N. Thomson). (2) Wreckage at Silver Beach where M. and Mrs. Jack Jones were drowned. (Thomson). **Bottom row:** (1) Jewett's yacht "Marilyn" photographed a few days before the storm. (Howard). (2) The same boat in the background (center) among wreckage on the shore of Great Harbor. (Thomson).

from Woods Hole.

At 9:36 I sent crews to rescue Mrs. Hughes in Pine Island. At 9:40 Mrs. Billings was reported to have been found at 7 o'clock. At 9:40 Ellis M. Lewis, caretaker at the Woods Hole Station, reported that he was still in the station and that the water was three feet deep at that time, but was rapidly receding. At 9:40 we sent Thomas D. Manchester and a crew of Barnstable fishermen to the Moors to do rescue work. Two cars had been reported to be turned over. The men found no one in them. At 9:53 a fire was reported by Mrs. Everett Noyes of Megansett. Upon investigation, it was found to be over the Bourne line. At 10 o'clock Joseph Grey reported that the south end of Mill Road was covered with water and was very dangerous. At 10:08 three Coast Guardsmen were reported to have been washed off the Coast Guard Patrol Boat *General Green* (they were later discovered drowned). Also Mr. Briggs and Mr. Neal were reported missing from Woods Hole (they too were later found

drowned). At 10:12 I tried to call the Bourne Fire Department with a request for flood lights, but I found that the Bourne Fire Station, with all its equipment, was under water. At 10:17 Officer McLane reported that Waquoit was O.K. At 10:20 it was reported a gas main, which was leaking at the Otis House in Maravista, was in danger of explosion. We notified the Gas Company.

At 10:20 more calls came from North Falmouth for rescue work at Silver Beach. At 10:42 the report came in of the rescue of the Law family at 6:30 at Menauhant. At 10:35 Dr. Goldberg reported on the lifesaving work at Silver Beach, which was done by crews in charge of Captain Albert Mullen, Captain John E. Overy, and Lt. Turner. He also said that the Jack Jones house had been completely demolished. At 10:35 a report came in that all the buildings on the Beach Road at Maravista had been inspected and that no one had been found. At 10:40 a call came from Chappaquoit Island in West Falmouth for help for a family of five who were marooned. I

sent Captain Mullen and the Nauset Coast Guard Crew to the rescue.

At 10:42 police protection was requested at Silver Beach, where, it was reported, vandalism was starting. We had the police notified. At 10:52 it was reported that the Harlow and Nickerson families would remain at Pine Island. At 10:55 a report came in that the men at the Florence Tea Room in Silver Beach would not leave and that two women had been rescued from there. At 10:54 another plea for a boat came from Chappaquoit Island, but a boat had already been sent. At 11 o'clock it was reported that Mrs. Rudd had been found at Mrs. Veeder's house in Woods Hole. At 11:09 a washout was reported at the Terrace Gables in Falmouth Heights. The road was reported as being in a very dangerous condition. At 11:11 Schoonmaker was again sent to assist the Espee family at Davisville but found them unwilling to leave. At 11:15 Wilson Erskine and Mr. Truslow of Woods Hole were reported missing (both were found to be safe the next day).

At 11:20 a report came through to the effect that the Clarence Cobb family at Wild Harbor was safe. At 11:25 it was reported that the Old Silver Beach Bridge had been washed out and that the Town Bath House had been completely demolished. At the same time it was reported that the Abbott family were safe at the home of Mrs. Deshon in West Falmouth.

At 11:55 no lights or power was available. Only the Central Fire Station phone was in order, and that because of the underground cable. The radio operator of the *Anemone* tried to operate a radio at West Falmouth but was helpless because of lack of electric power. At 12:20 A. M. it was reported that Tony Augusta of Woods Hole had started moving his stock to the Fire Station there, as his building was expected to collapse at any time. At 12:25 a request came in for kerosene oil to furnish fuel for the power plant at the Telephone Company. We complied. At 12:30 the telephone was found to be O.K. at the Woods Hole Fire Station. At 12:32 I directed every crew to stand by to go on patrol to inspect every building along all the Falmouth shores. Fifteen patrols were formed, each one having a truck and a skiff.

At 12:40 I sent a message to the Maxim Company in Middleboro that I wanted to either borrow or buy two pumps and some flood lights. Captain McInnis reported at 1 A. M. that he had personally inspected all danger sections in Woods Hole and that he had done all that was humanly possible to do.

At 1 A. M. I dismissed outside volunteers and crews and allowed them to return to their homes, but the Chatham Coast Guard Crew was determined to stay all night. At 1:04 it was reported that a La Salle car with a New Jersey number

plate had overturned at Nobska. No one was in it. At 1:15 serious gas leaks were reported at Cahoon Court on Main Street. We notified the Gas Company. Captain John Overy reported on Silver Beach conditions at 1:25 and said that they were very serious. At 1:29 I dismissed the Coast Guard from the Cape Cod Canal Base, and at 1:30 Captain Mullen reported having rescued the Nickerson family at Chappaquoit. At 1:37 a report came in from the National Guard Camp to the effect that it was impossible to get a message about the lights and pumps to Middleboro. I then detailed Arthur Eastman, Jr., to try to get through by car for them. The men stood by and continued patrolling all night. The storm was fast abating at this time.

Thursday morning we sounded No-School signals, as highways were impassable, either because of water or because of fallen trees. I had all the crews stand by all day, and they went out to lend their assistance on numerous occasions. All shore highways were closed by the Town Highway Department. The pumps arrived, and on Thursday morning the Fire Department started its work pumping out the cellars in the stricken areas. We started first with the Marine Biological Laboratory in Woods Hole. Then we went to the Bureau of Fisheries. After that we pumped out homes on Millfield and Water Streets in Woods Hole, homes on Millfield and Water Streets. Wild Harbor came next, and then West Falmouth.

We kept four pumps going continually. We had bought these pumps for this purpose rather than use the fire apparatus, as the sand and mire destroy the machinery. Two crews of men kept busy working on the fire alarm circuits. Eleven boxes had been destroyed during the storm, either by having trees crash down upon them, by being submerged by water, or by being burnt by high voltage electricity. I sent a signal out to relieve all men who had worked since early morning with a new crew, who worked all night on pumping.

On Friday the radio was fixed and we had direct communication with Plymouth. I saw the selectmen, and they authorized me to spend money on such things as were necessary in case of emergency. The Highway Department repaired the road in Woods Hole so that the apparatus could return to its headquarters on Main Street.

The Falmouth Fire Department members and the volunteers who worked under the Fire Department made 38 rescues in the Town of Falmouth during the hurricane, some of them at the extreme hazard to their lives, as in the rescue of the Cassidy children at Maravista by Captain Albert Mullen, Lt. McWhinnie, Lt. Fisher, William Mullen, and Fred Gaskell.

The Department tried as far as it was able to render assistance to all, by rescue work, by pumping cellars, by delivering radio messages, and by otherwise relieving distress.

The Collecting Net

A weekly publication devoted to the scientific work at marine biological laboratories.

Edited by Ware Cattell with the assistance of Boris Gorokhoff, Virginia Overy, and Katharine Silvia.

Entered as second-class matter, July 11, 1935, at the U. S. Post Office at Woods Hole, Massachusetts, under the Act of March 3, 1879, and re-entered July 23, 1938.

AID FOR THE YOUNG BIOLOGIST

One of the original objects of THE COLLECTING NET was to collect money to aid younger biologists in returning to Woods Hole in order to conduct independent research. Its net—over a period of a dozen years—has caught something over \$4,500 which has been awarded in \$100 scholarships. The money came in part from the profits in conducting the journal and from gifts, but mostly from the proceeds of plays, concerts and other entertainment sponsored by the journal.

Since these sources have been precarious, and the methods time-consuming and sometimes expensive, THE COLLECTING NET has evolved sounder methods for 1939. It is forming a membership association the expense of which will be carried by the journal. Therefore the full amount of each membership fee will go towards a scholarship. In the establishment of this new organization, THE COLLECTING NET Scholarship Association

has had the active cooperation of influential biologists. In particular, the executive committee of the Board of Trustees consisting of Dr. H. B. Goodrich, Dr. Robert Chambers and Dr. Laurence Irving should be mentioned. Among others who have given advice and who are serving as trustees of the association or as advisors are: Drs. Harold C. Bradley, William H. Cole, Edwin G. Conklin, Caswell Grave, A. V. Hill, Columbus Iselin, E. C. McClung, Eric Ponder and T. Wayland Vaughan.

A number of individuals interested in the progress of biology, but not themselves biologists, have consented also to cooperate in the work of the Association.

THE COLLECTING NET—which is a sort of secretary to the Executive Committee—anticipates the collection of not less than five hundred dollars during the present year. Invitations to join this organization for promoting research work in biology will be extended soon; we know that many an "alumnus" of the Marine Biological Laboratory will cooperate in the work of the Association. We believe that through their help and the aid of certain friends of biology it will be possible to award scholarships during 1939 and to begin building up an endowment fund.

In spite of the damage to Laboratory property caused by the recent storm, the M. B. L. Supply Department is prepared to fill orders promptly.

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M. B. L. LIBRARY AND THE FLOOD

The Marine Biological Laboratory was very fortunate in the fact that no water touched its library in the tidal wave during the hurricane of September 21st. The basement of the brick dormitory where the set of duplicate reprints to the library were stored was flooded from the Eel Pond to a height of about four feet, the two top shelves throughout the room not being touched except for three of the racks which were pitched over. No record of the number of these reprints had been kept but there must have been twenty-five thousand of which ten thousand were untouched. After careful examination of the reprints that had been wet and dirtied by the flood water, it was decided by Dr. Packard and by Mr. Larkin and the Librarian that the time spent in trying to salvage even a part of these would not be justified by the results and the attempt to do so was abandoned. We very much hope that this loss will in time be made up to us by gifts of reprints that we trust will continue to come to us by the generosity of our investigators.

—Priscilla Montgomery, *Librarian*.

IN THE WAKE OF THE HURRICANE

March finds the drawbridge on the main street of Woods Hole as impassable as it was on September 22. A foot bridge costing \$5,500 was constructed in December. The State of Massachusetts is custodian of the broken bridge, but the Commissioner of Public Works states that his department has no funds to use in repairing it. No one seems to know when work will begin. Many people predict that work on the bridge will not be completed until the summer season is under way.

The building inspector for the Town of Falmouth states that twelve houses on Penzance Point suffered \$30,000 damages from the hurricane, and that over \$4,000 damage was done to other houses in Woods Hole.

Charles G. Starling, first class seaman on U. S. Coast Guard patrol boat, the *General Greene* stationed at Woods Hole was awarded the gold life saving medal of the U. S. Treasury Department on January 23 "in testimony of heroic deeds in saving lives from the peril of the sea" during the September hurricane. Specifically, it was given for saving the life of P. Milton Neal on Penzance Point at about the time that three of Starling's shipmates were drowned in rescue work.

A group of Woods Hole summer residents led by Mr. Theodore E. Brown of Boston and Nobska donated money for over fifty families in Woods Hole whose homes or belongings were damaged by water. Mr. Brown distributed the money—over \$2,500—just before Christmas.

A TRAGEDY AT SILVER BEACH¹

While a few of us girls were wandering around amid the debris at New Silver Beach the day after the storm, we came upon a house which had been turned diagonally on its cement foundation. Water had entered the cellar, which was visible from the street, in its path of destruction. We sauntered over to investigate, having no idea of what that watery cellar held.

Two men wearing rubber boots were in front of the house, and one was walking around on the articles which protruded above the waterline in the cellar. Both turned around and quickly stopped talking at our approach, but not quickly enough, for we heard one say, "We'd better get the old lady out, hadn't we?" The other man's response was a rough and muffled, "Shut up!" Of course we didn't know what they meant; we started to scout around also. They repeatedly told us they were looking for beer. But they said it so often that soon we began to feel as if "something were up." "Looters," we thought. We kept poking around, finding odd things such as shoes, preserves, underwear, kitchen utensils, false teeth.

The two men seemed to resent our presence so much that we decided to leave. After wandering through the part most badly struck, we came to a place in the road where a part of the street had formed a bridge, but had been swept away by the terrifically rushing, raging waters of what had formerly been a small, winding stream. This seemed to end any further plans of exploration, but a board about eight feet long lying under a tree gave us an inspiration. We laid this across the biggest of the boulders for a hand rail. Then, after taking our shoes off and throwing them onto the opposite bank, we waded across by means of the most secure stones. The current was so forceful that very often they were swept from under our feet and down stream.

After finally getting across and finding nothing of particular interest, we went back again, all of our labor wasted. Anyway, we had a peculiar feeling about those men and couldn't help thinking of them. We reached the house and they were still there, but they were unconcerned and conversed with us. That was odd. Every time anyone found a piece of a torn garment or a strand of hair, the men would laugh shakily.

Then groups of sight-seers arrived, so we went home. There upon glancing at the newspaper I saw an article on the front page which sent chills up and down my spine. There had been a woman trapped in that very cellar, and those men had been waiting for us to go away before they took her out, dead. We had known something out of the ordinary was happening, but we hadn't even thought of a woman's corpse in the cellar. This explained the shoes, preserves, underwear, kitchen utensils, false teeth, etc.

—Betty Davis

¹Lawrence High School student prize essay.



CHANGES BROUGHT ABOUT BY THE HURRICANE

(Top, left) View of boats and debris on beach with the Breakwater Hotel in the background (W. B. Harrison); (Middle) Boats aground at Little Harbor. "Whistlewing," Kidder's boat, is on the tracks (Ferrer); (Right) Burt Little's motor boat hanging from the fence by its propeller in front of the laboratory apartment house (Cattell). (Second row) The channel which turned Penzance Point into an island. Three Coast Guardsmen lost their lives in rescue work at this point (W. B. Harrison); Main Street, Woods Hole, with the stone building in the background (Cattell). (Third row) The car in Salt Pond (Shore Road to Falmouth) where Miss Maurrer was drowned (Harrison). A section of railroad under water between Woods Hole and Falmouth (Ferrer). (Bottom row) Two views of the second foot bridge which runs over the Eel Pond behind the stores on Main Street (Silva); The Hughes' house on Penzance Point after the storm (Silva).

THE HURRICANE OF SEPT. 21, 1938, AS WITNESSED FROM THE COAST AND GEODETIC SURVEY VESSEL "GILBERT", AT WOODS HOLE, MASS.

LIEUT. CHAS. M. THOMAS

Commanding Officer, U.S.C.&G.S.S. Gilbert

For several weeks prior to the arrival of the freak hurricane that recently hit this part of the Atlantic Coast with such destructive consequences, I had been reminding my officers and crew that we should be on the lookout for the usual "equinoctial storm", which annual occurrence is supposed to occur sometime during the latter part of September, according to the belief of many mariners and lots of other weather-minded folks. That there is anything to it is debatable, but I prefer to remain a believer. However, little did we realize just what kind of a destructive storm was in store for us this season.

On Sept. 19th I learned from the usual daily weather reports that down in the lower latitudes, in the vicinity of the West Indies, the native home of many destructive hurricanes, another bad one had just been born and was brewing around, trying to decide on its course and speed. The next day the weather reports showed this disturbance to be progressing in a northerly direction towards the rough and stormy vicinity of Cape Hatteras, but not at an abnormal speed for such storms.

On the morning of Wednesday, Sept. 21st, this storm was reported to be about 75 miles off Cape Hatteras, and progressing up along the Atlantic Coast in a NNely direction. Small-craft warnings were issued, and winds of gale force were predicted for this vicinity of the New England Coast. As the difference in latitude between Cape Hatteras and Woods Hole is about $6\frac{1}{4}$ degrees, (375 nautical miles), and if we assume the storm to have an unusually fast progressive speed of 18 miles per hour, it would have taken the center of it over 24 hours to travel from Cape Hatteras to the southern coast of Massachusetts, making its arrival in this vicinity sometime Thursday morning. Had it behaved like the general run of hurricanes that travel up the Atlantic Coast, this would have been about the time of its arrival, giving more time in which to get prepared for it, and it would have accommodated us by shifting its course farther to the right, veering off to eastward, with its center passing us to the eastward, well out at sea. The winds during the passing of such a storm would have swung around to the left, from NE to N to NW, thereby having a tendency to lower the tides along the coast. However, the recent hurricane was not so considerate, its center having a course farther around to the left, causing it to come inland from the sea in the vicinity of the western end of Long Island, and thence up through the New England States, wrecking many vessels of various sizes and caus-

ing an unprecedented high tidal wave to pile up along the New England Coast, due to the terrific winds from the southeast and south blowing such an immense volume of water in from the sea. This is the reason that the seaports north of Long Island fared so much worse than those south of it but relatively close to the center of the hurricane.

The morning before the hurricane hit this section the barometer was fairly steady, the storm's center being supposed to be off Cape Hatteras. As the sea was not calm enough for our doing launch hydrography on Hedge Fence Shoal out in Nantucket Sound and as I thought it would be at least a day or two before the storm arrived in this latitude, I sent out a working party, in charge of Lieut. Lushene, over to Naushon Island, about 2 miles distant, to take down our survey signals, as I had previously promised Governor W. Cameron Forbes that this would be done when he had so kindly given me permission to erect our signals on the extensive Forbes property at the beginning of the season. Before the party left, I gave Lieut. Lushene specific instructions that in case the weather got too breezy and Woods Hole passage too swift and rough for him and his party to return to the *Gilbert*, he was to be sure to get in touch with me by phone through the office of Mr. Goffin, Local Superintendent of Fisheries, and let me know whether to go for him with the *Gilbert* or whether he would arrange to stay over on the Island.

I contacted Mr. Goffin at about 2 P. M. and told him about the phone message that I had been expecting from Lieut. Lushene. About an hour or more later Mr. Goffin came over and told me that Lieut. Lushene wanted me to call him up, and I promptly did so. He told me that he had made an attempt to return through the Passage in the launch, but that the adverse current and wind had been too strong and that he had given up the attempt and had returned to Naushon Island, where he expected to secure the launch safely in a small cove, well secluded, and return on the small steamer which the Forbes Estate operates between Naushon Island and Woods Hole and which was to leave at 5:25 P. M. I told him that this was agreeable to me, as the launch would very probably be safer and have better protection over there than over here in the exposed harbor.

That afternoon the barometer started dropping very rapidly for a while, at the rate of 0.10 inch per hour, leading me to believe that the storm center was only about 100 to 150 miles away and, as the increasing wind was slowly shifting around



for a while was expected to tumble into the water. The store foundation cannot be rebuilt until repair work on the bridge is completed in May. (E. Higgins). (4) The same view a few hours later. The shattered front window of the store is being boarded up. (E. Higgins).

to the right, from southeast to south, that the storm's center would very probably pass a short distance to the west of us. Had the wind continued to blow from the same direction with an increasing intensity, I would then have expected the center to pass directly over us. However, several hours before noon I had notified my Bos'n of the approaching storm and told him to take in all awnings and other canvas, secure everything, and assume that the center of the hurricane would pass over us whenever it did arrive, and govern himself accordingly. It was very fortunate that we took all necessary precautions in plenty of time, since this storm, instead of coming up the coast at the usual progressive speed of a hurricane, seemed to become transformed into somewhat of a severe cyclone, with a speed of 50 miles or more an hour and with wind velocities of from 75 to 100 miles an hour. I have had to dodge typhoons in the Philippines, and on July 26, 1932, had the center of a terrific typhoon pass over our vessel, the USC&GS Ship *Pathfinder*, while anchored in San Vicente Harbor, off northern Luzon, when the barometer dropped to 28.12; but never before had I experienced, nor have I ever heard of, a hurricane or typhoon that so swiftly swooped down upon an unprepared and unsuspecting populace with such destruction to life and property.

Captain Olsen, of the *Iduna*, the Naushon steamer, after observing the wind's unusual velocity, as shown by his anemometer, decided to cancel his 5:25 P. M. trip to Woods Hole. However, in the meantime Lieut. Lushene had wisely decided to remain over there with his party and not return, even if Captain Olsen decided to make the trip. He tried to notify me by phone as to his changed plans, but by that time the phone service was disrupted to such an extent that he could not get word to me.

In view of the approaching bad weather, we had secured the *Gilbert* along the north side of the Coast Guard dock with four 5½-inch mooring lines on each of the following: bow, stern, forward, and after springs. However, because of the way the wind and sea were increasing their intensity, I decided that all these lines were not strong enough to hold the vessel to the leeward side of the dock. To avoid the *Gilbert's* fetching

TRANSPORTATION THWARTED

Top to bottom: (1) Cars swept from Dyer's Dock, Woods Hole. A photograph of the dock taken near the height of the storm is reproduced on page 25. (J. Silva). (2) Concrete crumbled like a cracker. The drawbridge at Eel pond, with the steel gates on either side. (W. B. Harrison). (3) The undermined foundation of Rowe's Drug Store, which

up on the beach with most of the other boats in the harbor, I had the starboard anchor dropped and the port anchor chain unshackled and led across the dock to a dolphin. While this was being done, the bow line parted; and a short while later one of the lines to the after spring parted, five mooring lines being parted. In addition to the bow anchor chain, we broke out a brand new hawser and led it across the dock to another dolphin farther ahead and secured it to the towing bit. We also replaced two of the other bow lines.

While this was being done the tide continued to rise very rapidly. About two hours before time for maximum high tide, it looked as if almost everything was going to be flooded in this vicinity, including our storeroom ashore in the basement of the Coast Guard recreation building. The Bos'n, with two men, was immediately sent ashore to recover our instruments and move them up to the next floor before they got flooded. Everything had already been done aboard the *Gilbert* towards securing her as safely as possible, all available mooring lines aboard being now in use.

The Engineer was standing by (as he did throughout the night), ready at any time to go ahead on his engine in case the dock collapsed or all mooring lines parted and we had to depend upon our anchor to keep from being blown ashore. Much wreckage of various descriptions, including many boats, was being washed upon the beach around the north side of Great Harbor, and lots of wreckage was being washed up onto the dock and against the starboard side of the *Gilbert*.

After the Bos'n and his party had placed the instruments safely out of reach of the rapidly rising water, they then attempted to return to the *Gilbert*, but because the water had risen to six feet or more above normal high tide, they had to wade to the lines of the Coast Guard boat, *AB-65*, and climb aboard. After about 15 minutes they procured a boat and went to the aid of a woman stranded on top of an automobile at the corner of West and Millfield Streets. They then returned as near as possible to the *Gilbert*, and finding everything secure and intact they decided to answer an emergency call from Mrs. Milton Neal to come to the aid of her husband and his father, Mr. Albert W. Neal, both marooned on a tele-

THE AFTERMATH

Top to bottom: (1) One of Captain Veeder's cabins resting against his house, where it had been carried by the heavy sea. Note the rowboat on his front lawn. (J. Silva). (2) The washout under the Hughes house on Penzance Point. (J. Silva). (3) Boats take to land . . . (Dr. Gookins) (4) (right) . . . and houses take to water. Prof. Cannan's bungalow in the Mill Pond where it had been carried from Gardiner Road. (J. Silva). (5) (right) Nobska bathhouse in Nobska Pond, after it had been swept across the road shown in the foreground. (W. Cattell). (6) The Bay Shore bathhouse 500 feet from its original site, marked by the cement steps.



phone pole where the water was flooding from Buzzards Bay across Bar Neck, on the Penzance Point Road. By the time of their arrival the elder Mr. Neal had been fatally swept away by the raging overflow of water from the Bay into Woods Hole Harbor, which had a velocity of from 8 to 10 miles per hour. After many unsuccessful attempts had been made by others with inadequate lines, the Bos'n having procured a strong line from the house of the Harbor Master, Mr. Charlie Grinnell, helped carry the line out across the swiftly flowing water, and made it fast to the pole, so Mr. Neal could get safely ashore. After this, the tide receded sufficiently for the Bos'n and his party to return to the *Gilbert*, where all was still safe and secure. It was in this vicinity that the three men from the Coast Guard Patrol Boat *General Green* lost their lives while doing rescue work. At least 500 feet of the roadway to Penzance Point was wrecked in this vicinity. The extreme high tidal wave in Buzzards Bay also flooded over Millfield Street for quite a distance, with the water about 6 to 8 feet deep, well over the tops of automobiles. Juniper Point was also cut off by the water breaking through from Little Harbor. The large bath house at Nobska Beach was washed across the highway and deposited in Fresh Water Pond. The storm also wrecked the dock at Falmouth Heights, at the Casino, owned by Mr. H. B. Hopson, and also carried away our portable tide gage when this dock was demolished. A party of two officers and five men from the *Gilbert* combed the beach the next day in that vicinity looking for the tide gage and wooden float well, but could not locate them.

Lieut. George, the Engineer, the Bos'n, and I stood watch throughout the night, the storm subsiding during the latter part of the night with an abnormally low tide of about three feet below mean low water. The storm was practically over by 3 A. M. in the vicinity of Woods Hole.

A couple of hours after daybreak I went ashore to see the extensive amount of damage done by the hurricane and high tidal wave and also to see if our new tide house on the Oceanographic Institution's wharf was still standing. Naturally I was greatly relieved to find that it was still there and entirely undamaged, much to the credit of the recent builders, Mr. Forest E. Boynton and Mr. Milton Neal, the latter being the gentleman who

was rescued after having been marooned for quite a while on a telephone pole. The tide house had received a terrible pounding from the waves and wreckage, which had washed up against it, the extreme high water being $3\frac{1}{2}$ feet above the wharf and even with the door knob of the tide house. A description of the construction of this new, modern tide house was given in the August 27th issue of *THE COLLECTING NET*.

No damage was done to the party marooned over on Naushon Island, where they were well taken care of in the home of Mr. Allen, Overseer for the Forbes Estate. However, the hydrographic launch, which had been secured to a moored float, had gone adrift, along with the float, when the extreme high tide had broken it loose from its moorings, and they had both floated together for about a quarter of a mile due north, and had fetched up on the beach, in the edge of the woods on the southeast side of Uncatena Island. The launch had not been damaged at all, and undoubtedly had fared much better over there in that landlocked harbor than it would have done over at its regular berth alongside the Coast Guard dock, in spite of the fact that it was perched high and dry on top of a steep bank at least ten feet above mean low water. Practically all hands had to work all day Saturday before the large launch, a former Navy motor sailer, was finally put safely back in the water. It might be interesting to know that on our way through Woods Hole Passage, Saturday morning, between 8:30 and 8:45, 60th Meridian time, it took the *Gilbert*, (making at least 8 knots) 15 minutes to go through the Channel, part of the time losing ground, due to the excessive current setting eastward through the Passage, the time being just about one quarter of an hour before the highest tide of the month.

It is very likely that many changes have been made in the depths in certain sections affected by the recent hurricane, but this cannot be verified until additional soundings have been made and compared with the original soundings. Many changes have already been noticed in the topography along the northern shore line of Nantucket Sound. These changes will have to be taken into account so that the present topography will be correctly shown on the new charts that are to be made of Woods Hole Harbor and Nantucket Sound.

THE HURRICANE AT PENZANCE POINT

DR. O. S. STRONG

Professor of Neurology and Neuro-History, Retired, College of Physicians and Surgeons

Our house is located on a long peninsula (about a mile and a half long) named Penzance Point. Woods Hole harbor (an arm of Vineyard Sound)

forms the inner, mainly eastern, concave side of the Point and Buzzards Bay the outer, convex side to west and north. These two bodies of

water are united by the Hole, a narrow passage forming the southern border of the end of the Point.

Penzance Point is connected with the mainland by a rather narrow neck. On this neck are the Hughes, Murray Crane, and Frost places, the latter nearest us and on Penzance Point proper. Immediately beyond our house is another narrow neck of lower land connecting with the terminal part of the Point, most of the narrowing due to a salt marsh extending in from the harbor. Beyond this neck is the Park place, with other houses beyond, the Warbasse place being at the extreme tip. The Hole forms the southern boundary of these places. The neck and salt marsh lie to the south of our houses, which are about a mile out on the Point and which consist of the main house, situated fortunately on a high bank, and a bungalow and garage on low ground only about twenty feet from the waters of Buzzards Bay. Across the road, which curves around our house to the east, is the Briggs' Cottage, both road and cottage on much lower ground. Mr. Briggs was gardener and caretaker for the Parks. He lived with his wife, who is an invalid, and a younger son. He was a fine man, and we shall miss him very much.

During the morning of Wednesday, September 21, there was a warm southeast wind. As it in-

creased we wondered whether it could be in any way connected with a hurricane reported down Florida way, but we were told it was only an ordinary "Southeaster." In the afternoon the wind steadily increased, and at about three o'clock I phoned to the Kidders saying it was too risky to venture out to the Point in their car. Also it had begun to rain and they had an open car. If they had put the top up the wind would have taken it off, or possibly overturned the car. I phoned to Stockard, and he said he would not try to come out to get me unless the wind went down. He told me to phone again at six. This now seems so absurd.

At about this time the electricity went off. Also about this time we noticed the sloping mast of a boat ashore off the Brooks's place, nearly opposite Will's place, and Will's copper shingles being removed from his roof. We phoned to Will, and Lillian said Will had been picking up those he could reach—some were blown into the Bay, but there was little or no leaking because there was a wooden shingle roof under the copper one. At about this time, too, we noticed the Park boat house floating towards Will's dock, where it finally came to rest. No material damage was done to Will's boat, by the way. Then the telephone went out of commission.



"NO PARKING" ON MAIN STREET

This sign was punctiliously observed! Main Street between the Woods Hole Fire Station and THE COLLECTING NET office. (W. Cattell).

VIEWS NEAR FALMOUTH HEIGHTS

Upper: The washout in the main highway at Maravista, a quarter of a mile from Falmouth Heights. About a dozen persons were rescued near here by Captain Ferris of the Woods Hole Fire Station and his crew, using a patrol wagon and ropes. **Lower:** A house washed from its foundation at the entrance to the Inner Harbor at Falmouth Heights. (Baker).

All during Wednesday the scene was wild beyond description. Even before the rain, when Tommy went out on the porch, she felt spray from the harbor on her face. The marsh was a lake, and everything was indistinct through the mist of flying spray and rain. The surface of the water was torn off by the wind.

Later in the afternoon I made my way down our driveway to the bungalow. In front of it, next to the Bay, the waves were beginning to dash over the ground. I went into the bungalow by way of the garage and began to roll up the rugs and put them on chairs. Soon after, Tommy joined me and we finished the job. The water was coming under the sills in increasing quantity. We placed some rugs against the sills to diminish the intake, another ridiculous thing.

Shortly after this I noticed that some waves from Buzzards Bay were beginning to dash over the Park stone wall and onto the roadway. Not long after, while we were standing near our garage, we noticed Mr. Briggs wading around there. The water then was running swiftly from the Bay across the road to the marsh, and the wind had shifted from the harbor, *i.e.*, from southeast more to the southwest, and thus rather more from the Bay. At first it did not seem to be over Mr. Briggs's boot tops but he hesitated, apparently not feeling sure he could get across to the Park's, where he had been. It may be that the roadway was beginning to be torn up. The water rose so rapidly that the situation grew serious, and his son, who was standing by us on our roadway, waved him back. He turned back and a huge wave knocked him off his feet. He got up, was knocked down again, and floated—or swam—away in the marsh, by that time a turbulent lake. I could see his head for some distance, and he threw up his arms once or twice and then disappeared. Tommy had brought a rope, but he was beyond reach. In the meantime, King, Will's chauffeur, Eddie Briggs, and another man got a skiff from Will's place and launched it from the board walk to Will's boathouse on the harbor near the Briggs's house, where the water was up

NATIONAL GUARDSMEN ON THE SCENE

Upper: National Guardsmen being posted at Woods Hole. The Woods Hole Oceanographic Institution is in the background. (W. Cattell). **Lower:** Even Guardsmen must eat! The kitchen tent and the dining table at the National Guard emergency headquarters at Falmouth. (W. Cattell).

to the Briggs's first floor. King made a brave effort to get out in it but could not get beyond the pine tree back of the Briggs' house. At about this time Mrs. Briggs was carried up to our house and put to bed. Briggs's body, covered with debris, was discovered on Friday afternoon on the harbor beach at the Tilney place.

In the meantime we heard that we were cut off from the mainland. At about 6:00 p. m. I rode in a car with Eddie Briggs and a helper of the Parks' towards the entrance to the Point. The water was over the road in front of the Jewett's, next to the Frosts's, and I walked over the Jewett lawn to the Frost place. Over the whole Frost place with a deep, rapid torrent from Bay to Harbor; of course surrounding the Frost garage, where Mrs. Anderson, our helper, lives, and also the main Frost house. Beyond, the water was over the first floor of the Murray Crane house, and further, the Hughes's house was evidently also inundated.

I also made another trip to our bungalow. I could go near it only on the high bank to the north and could see a heavy surf pounding the lower part on the Buzzards Bay side of the bungalow, and also the whole bank way above the rip-rap.

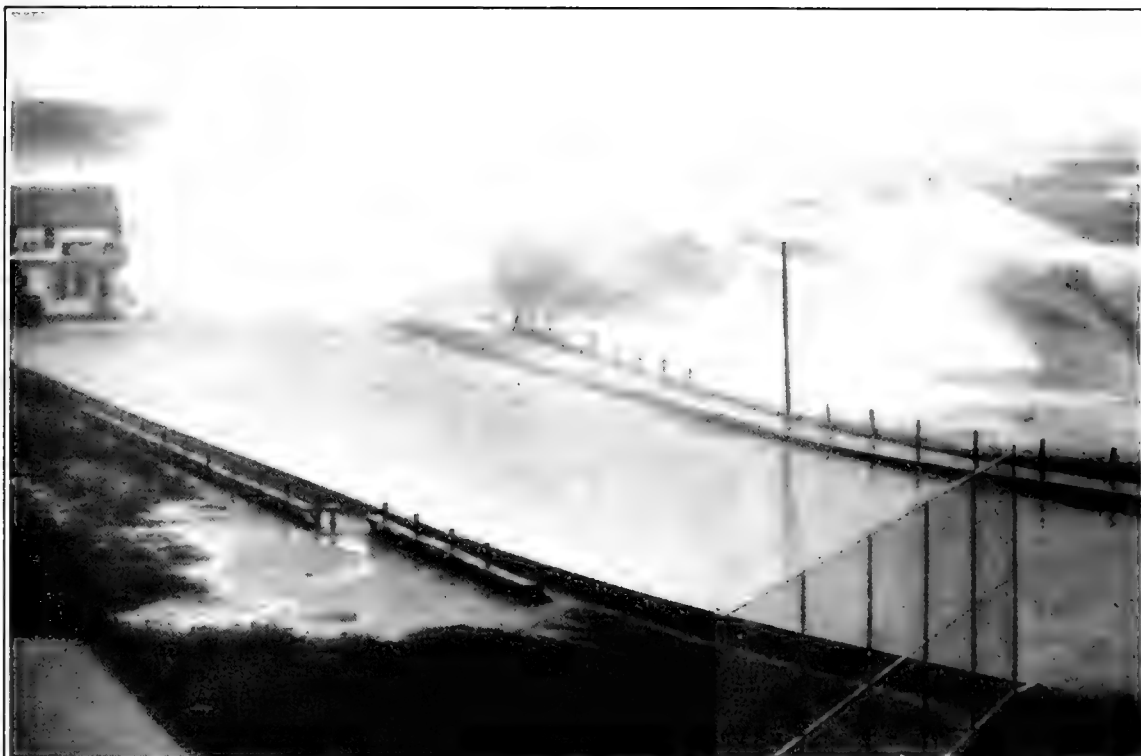
After dark, when the tide had gone down, I went out again with an electric torch and found I could enter the bungalow. The whole side towards the Bay had been torn off, except the living room, from which the shingles had been removed. The fact that the shingles were removed from the whole Bay side above water and also from part of the south side, where there was no surf, indicates that the wind played an important part in making the damage. The wooden floor of the dining room was mostly torn up and gone. Nothing was left in the room. The kitchen was swept as clean as a whistle. We found the electric refrigerator on the roadway nearly in front of the Briggs's house and the gas range in fragments. Other articles were found next day strewn about; some around in the Briggs's place and some along around the board walk to Will's boathouse. A number of rugs and cushions were recovered. The bedsprings and the bed mattresses were upside down in bedrooms. The day beds were still in the living room. The piano was lying on its back. There was some crockery on an upper shelf in the pantry. The wall between the dining-room and bedroom was intact, but the lower parts of the Dutch doors were gone. I had seen one front door somewhere around the main roadway, and parts of others elsewhere. The floors of the bedrooms and the living room were intact as also was most of the tile on the kitchen floor. Most of the cement floor of the dining room and the kitchen was intact. The cement

foundation in front was intact in the middle but removed at corners. The roof was intact and garage entirely uninjured. Nearly all the soil in front of the bungalow was gone; the rip-rap was practically intact. The bank above the rip-rap to the north of the bungalow was torn away leaving a flat, possibly useful, place. A fine, sandy beach had formed from the jetty to the north of the bungalow and extending beyond the jetty.

Mrs. Anderson had a narrow escape. She was in the Frost garage, and when she saw the water rising she went to the Frost main house with her boy. There she found five Coast Guardsmen with cars. She went back to the garage to get something, and when she returned to the Main house the water was beginning to flow over the grounds. They decided to go to the Breakwater Hotel on the mainland. One of the Coast Guardsmen took the boy on ahead and got there, but the man unfortunately started to return and was washed away and drowned. When Mrs. Anderson and the others reached the Murray Crane house, the water was breast high. They broke in a window on the first floor and were greeted by a flood coming in the back from Buzzards Bay. Two went out for a life line in one of the cars parked by the house and were swept against the wire net around the Frost tennis court. This net was torn away (the iron pipes supporting the net and evidently set in concrete were bent down against the ground), and they then hung on to the stone posts of the Frost entrance, to which a rope was attached, but were finally torn away and drowned.

Two men by the name of Neal, father and son, went to see about boats, were caught, and hung on to a telegraph pole opposite the Hughes's place until the father had to let go and was drowned. The others who were left in the Murray Crane houses remained there until the flood subsided.

All the low land of Woods Hole was overflowed, from the Gardiner's to the Frost's and back over the swamp, baseball field, Gardiner Road and Millfield Street (the street with the Catholic Church on it), the last having eight feet of water on it, just reaching the top of Swain's terrace. Two feet of water was over the bridge on Main Street, the bridge masonry was severely damaged and the street was torn up. One small store next to the bridge was swept away. The drugstore on the School Street side of the bridge was badly undermined. Other buildings were undermined, four to seven feet of water being in the basement of the Marine Biological Building, damaging furnishings and stock there. Part of the Bureau of Fisheries dock was gone and other docks were injured. Boats were washed up on land everywhere and boathouses destroyed. Mr. Griffin calculates the water near our house reached about nine feet above high tide.



THE STORM AT FALMOUTH HEIGHTS

Above: Waves breaking over the road near the baseball park. Howard's establishment in upper left hand corner. (Copyright, A. N. Thompson). Below: The Gables Casino awash during the storm. (Copyright, A. N. Thompson).

The long bathhouse on Bay Shore beach calmly floated over to Mr. Robert Baker's house back of the Breakwater Hotel. Two of Captain John Veeder's houses moved; one wedged in between his own dwelling house and the next one. The Cannon house on Gardiner Road, with Mill Pond at the back, is now against the opposite bank of the enlarged Mill Pond and partly submerged. A boathouse is picturesquely placed near the town "Angelus" in the Tower Garden bordering Eel Pond, also a boat.

Young Lawrie Riggs was rowing on Millfield Street. His boat capsized, and while swimming, his feet struck the top of a submerged automobile. The water came to just below the rise near the home of Bob Veeder, who gave refuge at various times to a score of people, including Eugenia Rudd (Gardiner) who spent the night with them. Mrs. Walter Garrey, whose residence is a one-story house on posts, was rescued by Teddie Chambers in a boat. They broke into the Copeland House—subsequently opened freely to all—and stayed there. Mrs. Garrey had to hang on to the roof of her cottage, I heard, before being rescued. Knowlton's house moved into the Garrey yard, intact.

Miss Billings and her mother, living in a one-story house on a high basement on Millfield Street, abandoned their house in a boat when the water was rising to the first floor. The boat capsized, but by means of a clothes-post near-by they managed in some way to escape the fate of the five men on Penzance Point. Young Ned Harvey had a very narrow escape while doing rescue work and was about all in when rescued. He was on the wharf near the Yacht Club House to attend to the boat. When the water came from the Sound he made his way to the tennis court on the Frost place. He hung onto the net, but was swept from that into the harbor. He got on a Herreshof boat, which was nearly submerged, and floated on that to the red spindle. While trying to swim back, he rested on a floating bar door, and finally landed on the Bureau of Fisheries porch in a dazed condition and all in. Young Borden, who was at first with Ned Harvey, also had a narrow escape.

The Meigs' houses were severely damaged, and their "studio," a small separate building, was turned nearly upside down in the yard. Practically all houses in the above mentioned locations were more or less filled with water, even though they remained intact and were not moved.

The flood came in first from the Sound—there was a high tide—and was re-enforced later by a flood or wave from Buzzards Bay, coming across the low land at the neck of Penzance Point over the bathing beach and between the Copeland's and Gardiner's. Frank Lillie saw the water advance

until it reached the base of his house. His family was prepared to go to the house behind theirs if necessary or to the high ground. The wind shifted from southeast to southwest, and he said if it had shifted to the northwest their house would have gone or been severely damaged.

Looting began soon, and not long after, the National Guard were called in. There were guardsmen at the entrance to the Point and at other strategic points along the streets and passes were required of people not well known. The Warbasse boat was rilled of compass and binnacle. Young DuBois chased away two young men attempting to enter his house on the Point. Miss Goffin saw a truck at the Angelus Tower and heard men inside the hedge say "Here it is," meaning either the boathouse deposited there or the boat also deposited by the tower. She asked a man to go with her into the Tower garden and there she asked them what they were doing. They said "Looking around." As it was 9:30 at night and pitch dark and they were smoking, she asked them to go out as the people did not want any fire risk. She told them to clear out, which they did. She reported their truck license number to the police, who not long after picked up the truck which was filled with loot.

Returning to the Point, the surface of the road was entirely removed from the Hughes's place to Frost's, and cut with deep gullies in places. The water could have been going through hardly more than two to three hours, but it was amazing how it dug holes in various places nearly up to a man's head, and overturned or broke through heavy masonry walls in some grounds, besides undermining and crushing in the ends of the Murray Crane and Hughes houses. Where there had been intact sod the surface was undisturbed, unless the water had got under it. The Frost tennis court and driveway were deeply cut out, but not the surrounding sod. The worst break was where Briggs lost his life. The whole low-lying ground was cut out and deposited in the marsh, including the masonry wall constructed by Park as protection against the sea.

Road builders repaired the road at the neck in about twenty-four hours, with, of course, only dirt; and in another forty-eight hours they had a dirt road across the gap between us and the Park place. The high tide nearly got them though, before they had the dirt sides covered with stone rip-rap. Even more will have to be done to make it permanent. Luckily my brother was still here and played a leading part in getting things under way. Mr. Jewett also helped materially, and the town said they would do the dirt part because it was their job to restore some communication.

Of course we were without electricity, both light and heat (oil-burner). For cooking we used

our "tank gas." Also we had no telephone. Candle light is dismal, but we had some good electric torches and finally got kerosene for some lamps we happened to have. Wood fire in the fireplace was adequate for heat. Water was never cut off entirely, but it might have been if Will had not discovered and reported a part of the water main bridging a gap which was about to give way.

Of course we could go on indefinitely picking up interesting accounts of other's experiences. I am confining this to what we saw on the Point, together with some incidents I came across in talking to people I know. Nor can any photograph give an adequate idea of the general appearance of things, with water-logged houses, debris of all kinds strewn on and along familiar village streets, the strange appearance of parts of the road on the Point, boats and boat houses washed up along the shores, etc. Much of the re-

moved portions of our bungalow are in the bushes along the road between the washout and the Briggs house, still more in the Briggs yard and along the side of the pocket where Will's boat house is. Jane, Tommy, and Mrs. Anderson have been busy picking up stray articles and Jane was quite overjoyed by the recent discovery by one of the men working at the Brooks place of some valuable linen they had left in the bungalow all folded up and tied up in a laundry bag. The linen was still folded up, but there was no laundry bag!

Later (September 29th) the remaining bodies were recovered. Mr. Neal's was found on the shore at Vineyard Haven, across the Sound, another body, of a Coast Guardsman, five miles out at a shoal, another on Nobska Beach and the remaining one floating near the U. S. Bureau of Fisheries.

THE WIND AND THE FLOOD AT THE BAY SHORE BATHING BEACH

DR. ETHEL BROWNE HARVEY

Investigator, Department of Biology, Princeton University

After leaving Dick at Exeter, we drove back to Woods Hole, arriving at about two o'clock. There was a high wind, which made the car unsteady on the road, and pedestrians on the Buzzards Bay bridge were obviously walking with difficulty. Somewhat alarmed by the wind, we drove immediately to the Yacht Club and found our sloop, the *Quo Vadis*, moored in her usual position. The wind was sufficient, however, to warrant a look at the storm signals at Nobska. There were no hurricane signals, merely storm signals—nothing to cause any alarm. Very soon afterwards the *Quo Vadis* and the *Molly*, the Meigs' yawl, were both dragging their moorings and were being rapidly blown by the southeast wind to the rocky shore near the Jewett's boat-house on Penzance Point. Every effort was made to save the boats by everyone there, including Hilton and his men, but in vain, and both boats were very soon battered to pieces on the rocks.

I got into my car to drive home, but found she would not start, owing to the heavy spray blown on her from the sea. She was marooned there for two days after the storm. Ned and I drove home in the other car; and everything seemed quiet on the Bay side. We changed our clothes, both being drenched to the skin. Then Ned walked over to Penzance, thinking he might help salvage other boats. He left me his car for use in case of emergency. Soon after he had left, I noticed our canoe in front of the house had been washed off its supports. Then the waters rose rapidly, soon reaching the brick terrace. Becoming alarmed, I took some boxes and bags of clothes and linen which were on my bedroom floor

to the second story, and also the Leica camera and the new binoculars which Ned had just rescued from the *Quo Vadis*. Then I rushed over to Penzance to get Ned to help me move other things upstairs. I could not find him with the Clowes and others and was afraid that he was on the other side of the water, which had already covered the road in front of the Yacht Club. I hurried back to the house. The water had just broken through from the Bay and was rushing down our driveway. I could not get to the house, so stayed on the steps of the house across the road. Soon the water came down the road and from the bath houses; and this, together with the stream through our lot and the Addison's, tore across Gardiner Road into Mill Pond. As the waters rose, parts of our porches broke away and were borne past me into the Pond. The dining room table, chairs, stools, doors, and windows sailed by in the current. Ned's car, standing in the roadway in front of the Jenkins', was gradually covered by the rising waters, till only the very top was visible. Possessions at this time seemed to me of little importance; the waters rising at this rate would soon engulf all the houses and ourselves as well. I looked around for the highest point on our little island for safety from the flood and finally decided to take refuge on the Widow's Walk of the Saunders' house. We were completely marooned, the Sylvas, Addisons, and I. And I could see the Garreys on their steps in water up to their waists calling for help.

The rise of the flood had stopped. The top of the car was still visible. Very quickly the waters went down. It had now grown dark, so we could

not see what had happened to our houses.

I was alarmed about Ned, and finding that the telephone at the Saunders was still working, tried to call up people on Penzance, but their phone service had failed. I finally called up the Fire Department to report that my son was missing. Just then Mr. Sylva came in and told me he was safe, having been taken in at Capt. Bob Veeder's. I learned next morning that he had tried to walk along the road near the Frosts' to come home but had been swept out by the tide, together with two Coast Guardsmen and Bou Borden. One of the Coast Guardsmen had tied a rope around the stone pillar of the Frosts' entrance. They all clung to this for a while, till the pillar gave way; then the Coast Guardsmen were swept out to sea and drowned. Bou Borden grabbed the Clowes' boat on his way out and stayed there till rescued some hours later. Ned grabbed another boat, at the time still on shore, and also a life preserver. The boat soon went adrift toward the Hole. Ned jumped overboard when near the Hole, and swam ashore, aided partly by a barn door, which he grabbed as it floated by. He landed on the Fish Commission front lawn, then well under water.

Mrs. Rudd, who had been marooned from her house and had sought refuge at Capt. Bob Veeder's, found Ned wandering around and somewhat bewildered and took him to Capt. Veeder's, warmed him up, and put him to bed.

The Addisons and I were given warm clothes and supper by the Sylvas and spent the night in the Saunders' empty house. Early next morning we went over to see what had happened. Our house was seriously damaged; it had been swung off its foundations by the surging waters; the chimney lay across the floor; the floor boards had floated up and were lying on top of the furniture. The electric refrigerator had been turned completely upside down. The water had come three-quarters of the way up to the ceiling on the first floor. The yard was covered with sand washed from beneath the house and was strewn with shoes, clothes, glasses (some unbroken), bottles, books, and pictures. Many of our possessions were across the road, and some of our window frames with unbroken panes of glass were recovered from the Redfield's lawn many blocks away. An unbroken egg from the refrigerator was found buried in the sand, along with a bottle of cream.



BOAT AND BOATHOUSE COME TO REST BESIDE THE BELL TOWER

Upper left: Boat house of Edward Swift left by storm near Bell Tower, Millfield Street. It was washed 1500 feet from the other end of the Eel Pond. (José M. Ferrer, Jr.). Lower left: Haskins' catboat "Clarissa" swept from anchorage in Eel Pond to the Bell Tower lawn. (José M. Ferrer, Jr.). Right: Tower flanked by house and boat. (J. Silva).



Top row: The beach on Surf Drive near Falmouth. The sandy bank in the first picture was washed away and the area levelled off as shown in the second picture. (Copyright, Fred S. Howard). **Bottom row:** The road beyond Nobska Point. On either side of Nobska the road was covered by more than a foot of sand, making automobile passage impossible. (Fred S. Howard).

PLAYING TAG WITH A HURRICANE

IDA S. SYLVESTER

Falmouth Forest Fire Observer for the State of Massachusetts

I am a Cape Codder, one of those strange people who can not sleep at night unless they first cast a weather eye at the sky and take the thermometer's reading and whose morning's coffee and toast grows cold while they tap the barometer and cock an eye at the old weather-vane on the barn. My grandfather shipped, in the traditional fashion, as cabin boy at the age of ten. My great-grandmother saw, from her widow's walk atop the old farmhouse at Nadasket, my great-grandfather's fishing boat disappear in a huge sea off Nantucket. Two hours later, as she was trying to stoically envisage a life of widowhood, my great-grandfather walked in, hale and hearty as ever, albeit a bit damp. Earlier forebears, I am told, also went down to the sea in ships. It

would seem that with such a salty heritage I should have a little sea sense. It appears, however, from the manner in which I played fast and loose with the hurricane and tidal wave of September 21, that I have none.

On Wednesday afternoon at about 3:30 I went to the West Falmouth Fire Tower (where I am observer) with Forest Ranger King. At that point, 230 feet above sea level, we estimated the wind to be blowing about 70 miles an hour, although this is not official, since I have no anemometer at the tower. Everything was fast at that time, although I expected the flagpole to snap at any moment.

From the tower I drove the patrol truck to Cotuit, as we wanted to leave a message for the

Barnstable fire observer. Large trees were going down in Mashpee; in Cotuit a fine old tree had crashed, pulling up considerable of the surrounding road bed and falling on the roof of the Cotuit Inn. In Cotuit Harbor several small boats had already capsized or been driven ashore. It was then about 4:30, and I was anxious to get home to my four-year-old son.

I arrived home at a few minutes of five, only to find that he had slept during the whole time of my absence. I spent the next half hour outdoors, battening down greenhouse sashes and making fast henhouse doors and other things which seemed about to take wing. I had put on a heavy coat because of the rain, which came in short, sharp showers. The air was oppressively heavy and warm, so I shed the coat for a thin cotton jacket when I got back to the house. I suggested to Dorothy Wright, the young girl who cares for my son, that we might all drive out to Wild Harbor, where we should see a "wonderful surf."

The three of us, and, as I now realize, my guardian angel as well, started out in the old Pontiac. Trees were crashing along the Silver Beach Road. As we approached the stone gates leading to Wild Harbor, a body of water loomed up. The road was well under water. Looking toward Silver Beach Harbor, we saw every craft afloat, cruisers, sail boats, and beetle cats, massed together and bearing down across the marsh toward the road. I'll admit our eyes popped open at the strangeness of that. It seemed to be a "high tide." My objective was still Wild Harbor Point, and for a mad moment I considered taking an old woods road that would take us around the further shore and out to the north. But the thought of the falling trees in the woods deterred me, fortunately. I swung around, and we went back to Silver Beach. We didn't get far there, for water was almost to the Blackinton House. I parked almost under the Blackinton flagpole with weather vane on top. The wind jerked to the southeast quarter, snapping the vane back and forth at lightning speed and at times seeming to box the entire compass in fierce gusts. We saw only one person, a man in hip boots, near us. He was pulling a skiff behind him, and the water was almost to his waist then. It stood about four feet high around the Florence Tea Room. We pulled out and went down the other road to Silver Beach. Again water met us. It was rising fast. Even as we watched, all manner of debris swirled across the road. I had to keep slowly backing the car as the water crept up to the hub caps. At that time I saw the Tonner home battered by surf and thought of Jack and Amy Jones, just below the Tonner's. I knew they stayed late in the fall and wondered if they were down and weathering

the storm all right. I still saw no cause for alarm. It was still a "high tide."

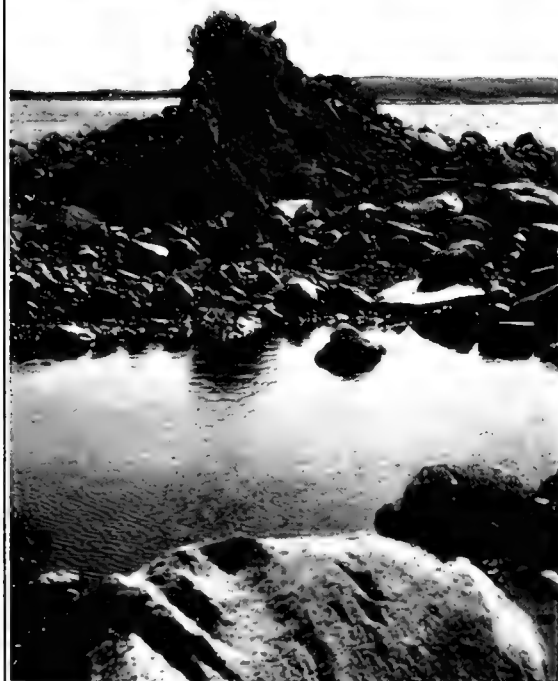
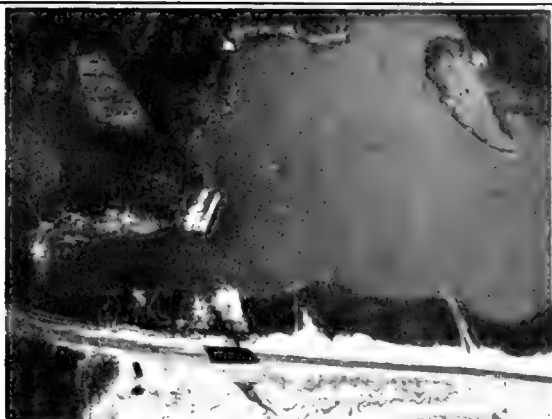
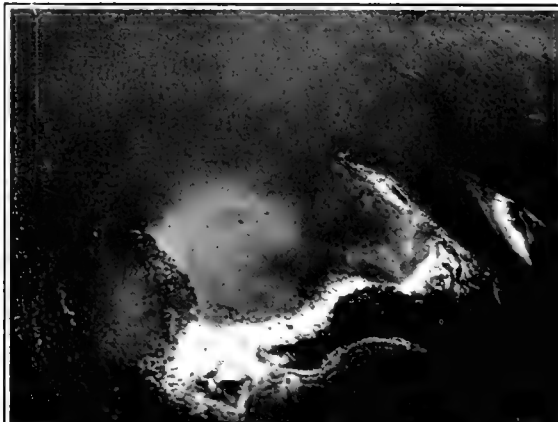
Still looking for surf, we took a run down to Camp Cowasset. On the bluff there everything below us was awash, and looking straight across we saw a solid sheet of water, with just the tops of a few trees to mark Crow's Point on the Bay Shores development.

I suggested we go to Old Silver Beach. We stopped to exchange a word with Pardon T. Leonard and his seven-year-old grandson at the Leonard home. We went on to Old Silver; Mr. Leonard and David went back to New Silver. They stayed there till 11 o'clock that night, trapped on the one high spot in the colony.

When we reached the parking place at Old Silver Beach, everything was going out, and going out fast. Poles and wires were coming down, water was beating across the parking space, the Old Silver Beach bridge rose and fell, and rose and fell again. Even as we watched, the small refreshment house on the further shore slid into the water. At the same time, a small, round area of shingles on its roof shot up into the air, as if driven by an explosion. The bathing casino was going too. All manner of debris battered at its outer walls. At last we saw surf, and plenty of it. The parking place was being torn away almost under our feet. The noise of the wind was spine-creeping. It shrieked like something alive.

My guardian angel must have shut his eyes for a moment because I decided to climb out of the car for a closer view, since the salt water made it almost impossible to see through the windshield. Dot got out too. As we left the car, the wind took us and ran us across the town parking place to where the dividing fence had been. The baby was alone in the car. The only way we could get back was by lying on the wind and fighting backwards a step at a time. When we finally reached the car and opened the doors, the doors almost blew off. By that time my guardian angel was back on the job. "If we don't get out of here, we're going to be trapped," I remarked. I wasn't at all alarmed though, just excited and getting a big kick out of the whole thing.

We just cleared a tangle of wires. I didn't like the wires, couldn't tell which were live ones. I had been out in the 1924 blow driving around, and it seemed to me this wind wasn't putting things down half as bad as the previous hurricane had. The Dam Pond crossing had been dry when we had gone over it, but now the fences were ripped off and it looked like mighty deep water there. I think my guardian angel yelled at me, but the wind was making so much noise that I couldn't hear him. I pushed the gas way down and drove the car into the water. I don't know how deep the water was because I couldn't see



EFFECTS OF THE STORM

(Cont. on next page)

anything. The water plowed over the top of the car. We reached the other side, went a few yards, and came to a stop. But, unlike Lot's wife, we didn't look back. I think the road bed went out then. The car started up in a few minutes, and we headed for Falmouth. I wanted to report the bridge out to the Police and Fire Departments. When we reached Underwood's Garage in West Falmouth, the water was up to the back of it, the railroad tracks were being washed out, and the water was up to the second stories on the houses at Pine Island. As I neared the Barclay, a man in a truck flagged me and told me I couldn't get through for the water was too deep across Route 28. I took the Brick Kiln Road and Gifford Street and reached the Central Fire Station in record time.

Men were coming and going there, and they looked pretty serious. It slowly began to dawn on me that this storm was more than just surf and wind. Chief Wells was at the switch board, and he was a busy man. I reported the Old Silver Beach Bridge out and the Barkley stop and asked what I could do. Chief Wells asked me to go to Maravista and see if eight persons who were trapped there had been rescued. I tucked the baby under my arm and went out. Just then the service truck drove in with Captain Ray Locke at the wheel. He said everyone was out at Maravista, so I went on to the police station. Sergeant Hamilton was there, with a couple of state police and Eddie Pearlstein. "Ham" was trying to answer both radio and telephone at once. He was sending out calls for doctors, boats, and help in general as fast as he could. It's no joke trying to handle both radio and telephone in an emergency, as I know from fire experience.

As I waited for "Ham" to have a free moment, Gunnar Peterson and a young fellow I didn't know came into the station. The other chap seemed pretty much shaken. I told him to go ahead of me, and the young fellow, who was Henry Maurer, told how he'd left his aunt in the car on Surf Drive while he had gone for gas. I guess he realized then that she was drowned. Meanwhile, I was writing down the information I had for the police on a piece of paper. I left it in front of "Ham", who took time out to say, "Thank you," and then I headed for Woods Hole. Emergency messages at both police and fire stations had sounded bad for that location. I saw Nate Ellis for a minute in front of the Episcopal Church, where work was going on at the big

trees, and told him of the bridge, water barriers, and trees I knew of. Nate was the calmest man I'd seen thus far in the storm.

There were a lot of trees down on Quissett Avenue, and it was beginning to get dark. When I reached the Gansett Road, I found the Woods Hole hook and ladder truck stationed there. "Pat" Peck called to me. I got out and got a load of what was happening up at that end of the town. Ellis Lewis drove up as we were talking, and I told him that his bath house had gone at Old Silver, but I don't think he believed me then. I went on down to the head of Millfield Street. That was as far as I could go, without pontoons on the Pontiac. Lt. "Mannie" Turner of the Fire Department was there. We all piled out of the car, and "Mannie" yelled to me to see if I could get him a skiff which was down in the Stuart yard. Mr. Stuart had been doing plenty of rescue work. A reporter came along, and I told him of the conditions in the north of the town.

The baby was skittering ahead of me in the wind, and I had to catch him and make him fast several times. "Mannie" suggested we go with him around to the other side of Woods Hole. However, when we climbed into his car he discovered that he had a flat tire, so we got back into the Pontiac. By then we decided to head for home. "Pat" suggested I follow the tracks of the truck across the Woods Hole Golf Links. My windshield wiper had blown off, so no matter how often I got out and wiped the windshield the salt spray came right back on. Also, golf is not my game. So, I lost the tracks left by the hook and ladder truck and got into the rough. I hit a couple of stones in the darkness, making an awful noise. My guardian angel was about ready to wash his hands of me, but he saw to it that I stopped the car just on the lip of a deep trap, but playing around that course that night was much worse than facing the hurricane.

I made a last stop at the police station on the way home. In West Falmouth I stalled in the water below Landers' Garage and had to be pushed out. I reached home and left the baby with my mother for supper and bed. He was in fine fettle. I put on another coat, as the tropical warmth had disappeared. When I went to get a drink of water, I found the pressure way down. I didn't know then about the dozens of torn-off mains at Silver Beach.

My guardian angel turned in for the night about then, I guess, but there was no more gas

(Top, right) Nobska bath house in Fresh Water pond. It was standing immediately in front of the parking space visible as a black rectangle beside the road. The trail leading into the pond near the lower right hand corner is the improvised road of sand made to pull a car out of the pond (Cattell). (Second row, right) High tide mark on Laboratory lawn. This picture was taken a month after the hurricane and shows the effect of the salt water on the grass (Silva). The other views depict the erosion of Devil's Foot Island. In the aerial view note the channels cut through at each end. Pine Island was swept away.

in my car anyway, and no pumps were working. I heard what had happened at Silver Beach and Megansett, so I climbed into someone else's car and went to both places. Later we drove into Cataumet for red lanterns and flares and set them up at washouts and other road dangers. We visited some folks who had been marooned and found everyone all right. At 3 A. M. at a house

in Falmouth Cliffs, I had a cup of hot coffee, which was the nicest I've ever tasted. Sometime after four o'clock, I went home and set the alarm to wake me in an hour and a quarter. As soon as it was light, I went out to view the carnage, which the darkness had so mercifully hidden all night. Not until then did I realize that I had been playing tag with a hurricane and a tidal wave!

WORK OF THE COAST GUARD MEN DURING THE HURRICANE

CAPTAIN THOMAS NOLAND

Commanding Officer of the *General Greene*

On the afternoon of the hurricane, the Coast Guard patrol boat, the *General Greene*, stationed at Woods Hole, was prepared to do its utmost in the crisis. We started by saving ships but in a very short time turned to saving lives, and three of our men, Haywood T. Webster, Frederick T. Lilja, and John A. Stedman, worked nobly indeed.

I will try here to relate to you some of the high points in the work done by me and my crew, both during and after the storm.

At 6:30, September 21, Machinist Frederick T. Lilja and myself drove to Penzance Point to investigate conditions where a number of people were trying to secure their yachts to the piers to keep them off the seawall. We returned to the *General Greene* immediately and took all of the crew, with the exception of four men who were left aboard in charge of Paul S. Peckham, and then drove out to Penzance Point. We took a coil of rope and a heaving line along in Lilja's car.

The wind was increasing rapidly and several yachts that were anchored close in had dragged anchor and were against the sea-wall or on the beach. The wind and sea had increased to where it was impossible to do anything for most of these yachts. Most of the civilians drove back to Woods Hole. Penzance was rapidly becoming an island. After pulling a yacht as far up on the beach as was possible we followed the civilians back to Woods Hole.

Cordice with men in his car were in front; Lilja with men in his car next, and myself with men in my car following. Lilja's and Cordice's car stalled due to water getting into the engines; we pushed them to high ground, and then we all left on foot for Woods Hole. Near the Crane residence we met Mrs. Nellie Anderson searching for her twelve year old son, Dennis. Lilja, Webster, Stedman, Cordice and myself took up the search and found the boy near the Crane's garage. We located Mr. Charles Blumeaur near this place.

At this point we started once again for Woods Hole. Stedman led Mrs. Anderson's son Dennis

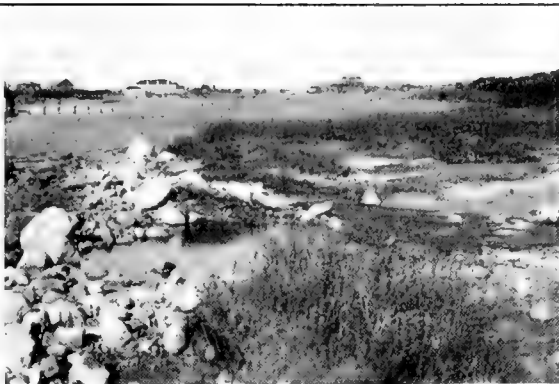
across to safety and then started back to where we were, on the lee side of the Crane residence. I saw a wall of water coming from Buzzards Bay and motioned for him to go back, but the current was so strong that it was impossible for him to go either way. He was holding on to a hedge until a second wall of water came; then he was carried away from the hedge to where he caught on to a telephone pole guy wire for a few moments. He was then carried away from the guy wire and went down. He was never seen alive after that.

After witnessing this tragedy we did not attempt to return to Woods Hole. Breaking a window of the Crane residence, Mrs. Anderson, Mr. Blumeaur, Cordice and myself got into the building and went to the second story. An eight foot wall of water was at that time sweeping over all the low land of Penzance.

Lilja and Webster were trying to reach the shelter of a small building about 100 yards from the Crane house, when they were caught by a wall of water which came in from Buzzards Bay and swept down into the tennis court near the building we were in. They held on to the wire around the tennis court for a few moments, until the wire was carried away; then they clung to a wire which was fastened to a cement post. A minute later two civilians were swept by, and they also reached the wire and clung to it. They held on to this line for a short time until they were all carried away. It was impossible to see what became of them, the visibility being very poor at this time due to the salt spray and the rain.

I was told that one of the civilians grabbed a boat mast out in the Bay and was rescued. The other civilian, it is understood, caught on to an anchor chain of a yacht and was rescued. The Coast Guard men were drowned. In my opinion this was about 6:30, when the wind and the tidal wave was at its height. The velocity of the wind was eighty miles at this time.

As darkness fell the water began to recede and we were able to get out of the building and take Mrs. Anderson and Mr. Blumeaur to Woods Hole. Cordice and myself returned to the *Gen-*



AFTER THE STORM AT WOODS HOLE

Top: Riggs garage on Government Street (Silva); Looking across to the Draper residence on Penzance Point (Harrison). **Bottom:** The Coast and Geodetic Survey Vessel "Gilbert," the morning after the storm. Note the debris on the wharf (Harrison); Roof of Jewett's boathouse on the beach (Harrison).

eral Greene where we immediately established and sent out searching parties. Other members of the crew were engaged in rescue work throughout the storm and they reported that a number of lives were saved by them.

The body of Webster was recovered at 8:30 A. M. September 28 in Woods Hole Bay and the body of Lilja was recovered at 11:30 A. M. September 28 at Hedge Fence Buoy, Nantucket

Sound; Stedman's body was found on Nobska Beach in Woods Hole on September 29 at 1:45 P. M.

The *General Greene* cooperated with the Falmouth Police Department, and continuous patrols were maintained on the beaches and with boats.

We did all in our power to help where help was needed and my men deserve much praise for their loyal and unflinching service and courage.

OPERATIONS OF THE FALMOUTH POLICE DEPARTMENT DURING THE HURRICANE EMERGENCY

HAROLD L. BAKER

Chief of Falmouth Police Department

On Thursday after the hurricane of September 21, 1938, I used all special and civilian aid that I could find to prevent looting. On Friday reports of looting were still coming in from areas around Silver Beach and Woods Hole, and the situation became so serious that Saturday morning Selectmen Frederick T. Lawrence and Charles R. Stowers authorized me to call in the National Guard.

11:35 A. M. Saturday marked the arrival of

the first detachment of twenty-five men, who were under the command of Captain William P. Hunt of Battery B, Commonwealth Armory, Boston. I met the men at the Police Station and detailed one truck to Patrolman Eckhardt Sparre, who took charge of stationing the men for patrol duty from Menauhant to Woods Hole. I took the other truck to West Falmouth, where I placed the men at Black Beach, Chappaquoit, Silver Beach, and Megansett.

Six special officers from Barnstable, Harwich, and Yarmouth were placed at Woods Hole and East Falmouth. State Trooper Albert E. Goslin was stationed at Silver Beach. State Trooper George Killen stopped cars on the Wild Harbor Road. Special Patrolman Pardon T. Leonard of North Falmouth assisted him in recognizing property owners in that area.

After checking over the situation at Silver Beach with Patrolman Lester Baker and Special Officers Harry Randall, William Potter, and Reginald Bowman, I returned to make a tour of Woods Hole. Here I found two Guardsmen at Penzance Point with Special Officer Mogrado, another at the Woods Hole draw-bridge with a Hyannis officer, and another between the two points.

From here I checked with Sergeant Lewis S. McLane, who had been searching in vain all day for the body of Miss Alice H. Maurer, whose car had been swept into Salt Pond by the hurricane.

Next I went to Acapesket, where I met Mr. Leo Miskell. Although we encountered some difficulty at the approaches of the Green Pond Bridge, we were able to cross it. Mr. Charles White, Town Engineer, was stationed there and reported that everything was quiet at Davisville. Then we inspected property along the shore and found that considerable damage had been wrought by the storm.

Returning to the Police Station, I discussed plans with Brigadier General Roger W. Eckfeld, who told me that we had to find a place to quarter his twenty-five men. So after receiving permission, we stationed the men in the Community Center in Falmouth.

Other officers who reported at the station for duty were: Lieutenants William W. O'Hearn, Fred L. Fish, Harold Trefethorn, Francis H. Shepard, and Captain Robert R. Duncan of Battery A; Captain Hunt, Lieutenants William Gosman and Ralph Noseworthy of Battery B, all of the 101st Field Artillery.

With so much army protection property owners were finding it difficult to inspect their own property. The situation became so serious that I had to issue passes with my name stamped on them before one could gain admittance into the stricken areas.

We were busy all day Sunday, and Clayton Collins was kept busy at the desk issuing passes. Many persons came to the Police Station to get assurance as to homes, relatives, friends, and boats. We were busy all day Sunday issuing passes. The large map in back of Patrolman Collins at the desk was marked with colored pins showing the location of each man on duty. Both the radio and telephone were in constant use.

On Monday morning Fire Chief Ray D. Wells, Selectman Frederick T. Lawrence, and I went to Silver Beach. Rodney Hodgman was searching the harbor in a boat for the body of Mrs. Andrew Jones. Upon our arrival we found that 120 C.C.C. workers from Brewster had arrived to join in the search and clean up the debris. We put them to work under the direction of Harry Randall burning the rubbish and piling up the salvageable material, as Fire Chief Wells was in fear of spontaneous combustion.

Special Patrolmen were: Joseph G. Hewins, Vezzie Brackett, Gardner Blossom, Stewart Harlow, Clement Lino, Antone Mogrado, Lester Baker, Reginald Bowman, Manuel Mogrado, Neal Dolan, Lawrence Roderick, Jack Murley, Leonard Perry, Joseph Costa, Jr., W. H. Hewins, Jr., Pardon T. Leonard, Fred Sylvia, George Roderick, Harry Randall, Robert Leighton, Rodney Hodgman, Tyson Bartholomew, Elmer Landers, George Priest, Richard McLane, William Porter, and Raymond Crocker.

I would like at this time to express my appreciation to all the regular members of the Police Force, all the special patrolmen, and the National Guard for the excellent piece of work which they did in this department during the crisis caused by the hurricane.

SUMMARY OF THE DAMAGE DONE TO THE HIGHWAYS IN THE TOWN OF FALMOUTH

NATHAN S. ELLIS, JR.

Highway Surveyor for the Town of Falmouth

We will start with the Eel Pond Drawbridge on Main Street in Woods Hole. This bridge lost two abutments. We opened the bridge the next day to allow the fishermen to get out. After that we lowered it and stayed it to allow traffic to go in and out. We built a temporary walk for pedestrians. The work on it will start as soon as possible. Fay, Spafford, and Thorndike, of Boston, are the engineers for the State that will have charge of rebuilding.

Main Street in Woods Hole was badly torn up

by the storm, and it was necessary for me to have it repaired and rebuilt; but it is in very good condition now. The sidewalks in Woods Hole also suffered storm damage, but I have also repaired them.

Gosnold Road, Penzance Road, and Millfield Street were all pretty badly hit, but we have them in repair now. Nobska Road was greatly damaged and has been cleaned up as far as the Light. Beyond the light, there is a large fill to be made, but it will not be done at the present time.



THE "FRONT" AT BUZZARDS BAY AND WAREHAM

Top row: (1) Buzzards Bay Railroad Station at the height of the storm. (2) Main Street, Buzzards Bay, during the hurricane. (J. Tyson). **Second row:** Wareham under water during the hurricane. (E. C. Besse).

Beach Road and Shore Drive in Falmouth were storm damaged, but both are in good repair now. Menauhant Road to Great Pond has been cleaned up and is passable, but will have to have more work done on it later.

The Great Pond Bridge was damaged and will have to be rebuilt. From Great Pond Bridge to Acapesket the road was damaged, as were numerous sea walls. Green Pond Bridge was damaged by the storm, but, being built of cement, it stood up; however, the approaches and the railings were washed away. The Highway Department will take care of the approaches in the immediate future. It will not be necessary to have a new bridge here.

The Bourne Pond Bridge was badly damaged by the storm and will have to be replaced. The road from that bridge also will have to be rebuilt.

At Chappaquoit Island we will have to have a new bridge built. A cement structure will take the place of the wooden one, which is now impassable. The Chappaquoit Road will have to be replaced.

The Herring River Bridge at Old Silver Beach was washed over onto the beach and will have to be replaced by a new one of cement. There were many washouts along the old Silver Beach Road to the end of Curley Boulevard. The repair work is being taken care of by The F. Roach Co.

The little loss Silver Beach suffered in road damage was amply made up by property damage. The Wild Harbor Road suffered a small amount of damage, which this department will have to repair.

Narrow escapes were numerous when my men worked constantly for two days and a night during and after the storm, clearing the roads of trees which were making them impassable, but I am very happy to report that not one life was lost in my department.

My foremen, Mr. Joseph Rego Towers, Mr. Alfred Nickerson, Mr. Ralph Landers, Mr. Seth Collins, Mr. William Davis, Mr. Walter Small and my secretary, Mrs. Frank Hamilton, are to be congratulated upon the way which they took hold and helped me, and I think that they did a wonderful piece of work.

HEALTH CONDITIONS BROUGHT TO THE TOWN OF FALMOUTH BY THE STORM

DR. THOMAS L. SWIFT

Health Agent for the Town of Falmouth

There is no health menace resulting from the flood. However, this department has been advised through the State Department of Health to ask people to be cautious about all shell fish, with the exception of scallops, as the exact amount of pollution of the tidal waters has not yet been determined.

Accompanied by Mr. William H. Doggett of the Massachusetts State Health Department, Mr. J. Elliot Hale of Maine, Dr. H. W. Stevens, Health Officer for Southeastern Massachusetts, and Dr. A. P. Goff, the County Health Officer, I inspected the flooded areas and found everything in as satisfactory condition as would be possible.

The odor from Eel Pond and Mill Pond, which have been condemned for some time on account of pollution, is believed to be of vegetable origin and therefore is considered not a health menace. Mr. Hawley, bacteriologist from the State Department of Health, went to these ponds and obtained

several samples of water for analysis to determine the exact condition at this time. However, I hope that the people of Woods Hole will not regret taking advantage of their recent opportunity to vote for sewage, as the sanitary conditions in that section of the town will never be absolutely satisfactory until there is a sewer system.

Mr. George Crocker and Mr. Alton Robbins, sanitary engineers for Barnstable County, have inspected all flooded areas, and samples of well and spring water have been tested and found to be safe. The town water has been safe at all times.

There has been no contagious disease of any kind reported, and conditions are getting back to normal. This Department wishes to thank the people of Falmouth for their cooperation in cleaning up their property as quickly as possible. I have left no stone unturned to avoid all health menaces, and results show that my purpose has been accomplished.

DAMAGE WROUGHT TO THE CAPE TELEPHONE SYSTEM

HARRY L. CROOKS

District Manager, New England Telephone and Telegraph System

The storm of Sept. 21 caused the most wide spread destruction of equipment that the telephone system has experienced in its history.

At the end of the storm, approximately 204,000 telephones out of 1,223,000 served in the New England district were out of service. Workmen, who were removing wreckage, allowed debris to fall on and sever wires and cables. Men and boys cut important cables to obtain the metal to sell. This brought the total of telephones out of service to approximately 301,000. More than 300 communities were completely isolated from the outside world.

Apprehension for the safety of friends and relatives caused the number of calls to leap to 70% above normal with available facilities either wholly destroyed or at only 50% of normal efficiency.

Telephone trucks together with their crews of men were sent to stricken areas to help with the work of restoration. They came from as far south as Florida and as far west as Nebraska. In all, 16 states were represented among these repair crews.

The Falmouth area, which includes Buzzards Bay, Sagamore, and Wareham, as well as Falmouth, did not suffer as badly as some other nearby areas. The damage here was caused more by flood than by wind.

In this area out of 5118 stations 2124 stations were out of service at the peak of trouble. Service was restored and back to normal Oct. 6.

The most serious damage in this area was at

Wareham, where a bridge washout destroyed all cable communications with Cape Cod. This washout destroyed a 244-pair toll cable and a 400-pair local cable. The break occurred at 6:30 P. M. the 21st, and by 5:00 A. M. the next morning three circuits were in operation for long distance calls for the entire Cape Cod, Martha's Vineyard and Nantucket areas; by 10:00 A. M. four more circuits were working and by 6:00 P. M. a total of fourteen circuits were available. The toll cable was replaced and all circuits were in working order Sept. 25.

The patience of the public under adverse conditions made the telephone job a much lighter task. We are highly appreciative of the cooperation of the general public in our period of emergency.

Telegrams Sent from West Falmouth

Miss Edith E. Wright, Western Union Manager at Woods Hole was driving home to Pocasset early the evening of the storm when she was struck by a tidal wave which submerged her car. She was able after some difficulty to push the car door open and escaped to a nearby bank by the roadside in water waist deep. Undaunted she proceeded to the company's agency at West Falmouth and carried on there accepting telegrams for transmission up to a late hour that night in spite of the fact that her clothing had been previously water-soaked.

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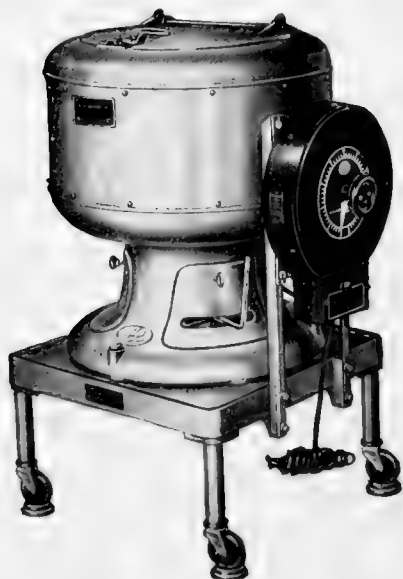
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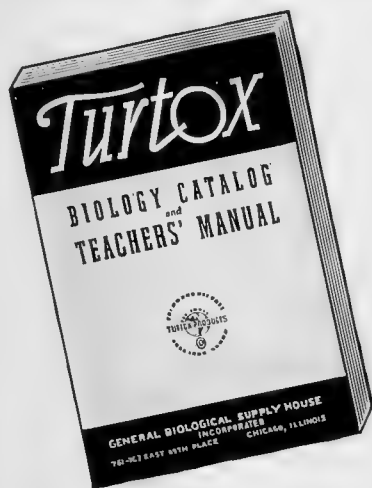
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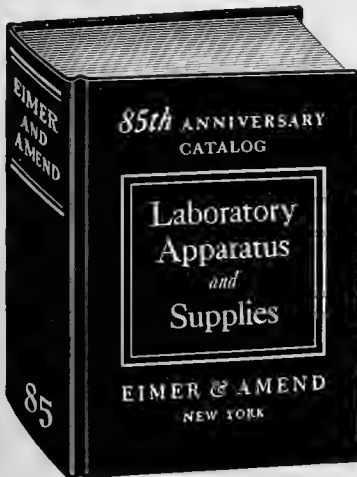
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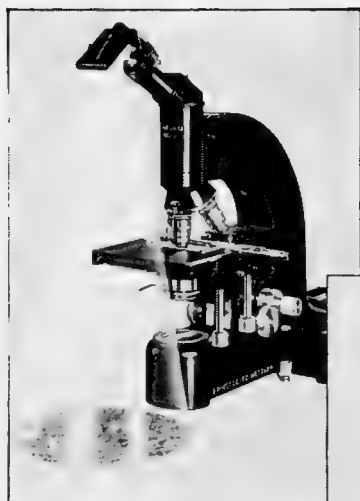
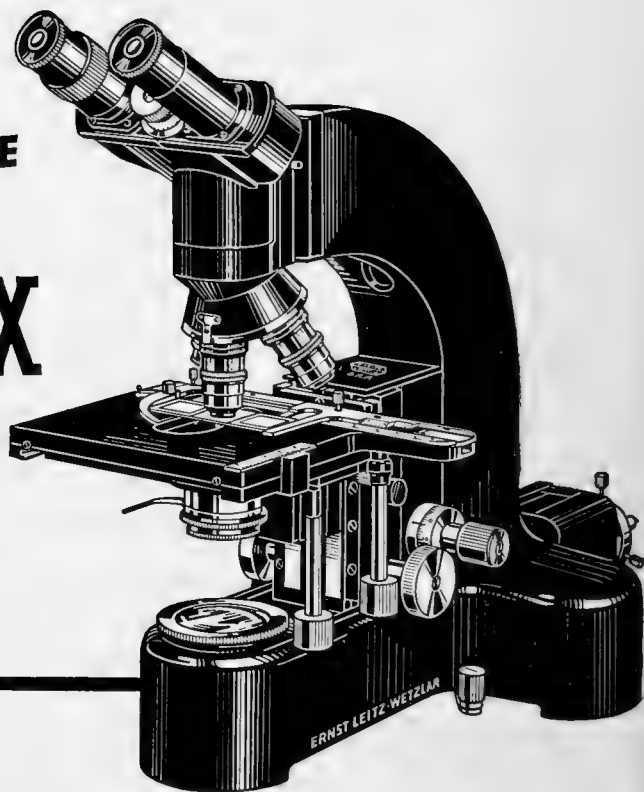
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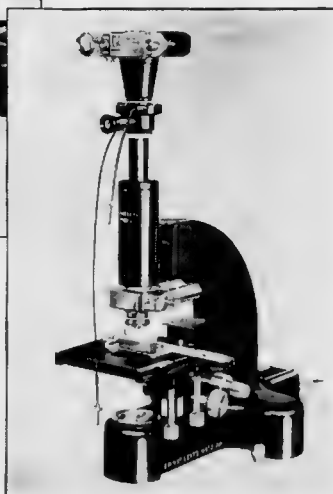
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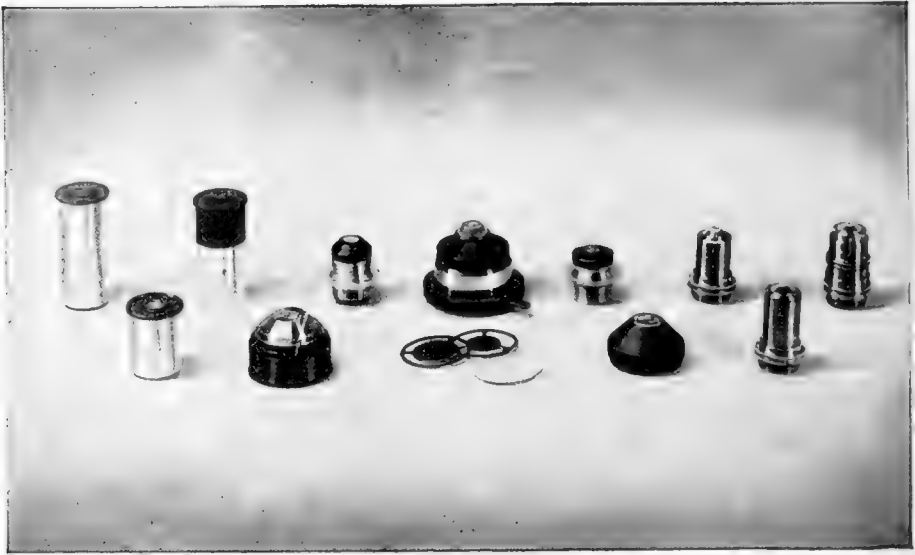
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Vol. XIV, No. 1

SATURDAY, JULY 8, 1939

Annual Subscription, \$2.00
Single Copies, 30 Cents.**BIOLOGICAL EXPLORATION IN THE
PACIFIC OCEAN**MR. JOHN S. GARTH
Allan Hancock Expedition

"Colorful Latin America" is the first all-color motion picture to be released by the Allan Hancock expeditions. Each year for eight years cruises to the tropical Pacific ocean have been made on Captain Allan Hancock's cruiser *Velero III*. Departures were made from the port of San Pedro, California, to such remote localities as the Galapagos islands, the Bird islands of Peru and the seldom-visited coasts of Colombia, Ecuador, and the central American republics.

Scientists who have accompanied these cruises included Dr. Waldo L. Schmitt, curator of marine invertebrates at the United States National Museum, Dr. H. L. Clark, curator of echinoderms at the Harvard Museum of Comparative Zoology, Dr. William R. Taylor, marine biologist at Woods Hole and the University of Michigan, and Dr. George S. Myers, ichthyologist of Stanford University.

The *Velero III* is an (Continued on page 12)

**TEMPERATURE IN EVOLUTION AS
SHOWN BY STUDIES ON DROSOPHILA**DR. H. H. PLOUGH
*Professor of Biology,
Amherst College*

In the writings on evolution of the older naturalists no form of physical energy loomed larger than heat as a causal agent in evolutionary change.

This was not only because its effects on living organisms are so obvious and so widespread but because the most rapid palaeontological changes appear to have occurred during periods of marked climatic disturbance. This form of radiant energy probably affects plants and animals in more ways than any other form, both because of its variations in time, diurnal and annual, and because of its extreme differences in distribution in space. Its marked influence on physiological processes, together with the ease with which its effects can be measured, have resulted in a larger body of literature on temperature influences and their interpretation than perhaps any other factor in the normal environment. In spite of these facts definite statements as to the influence of heat or tempera-

M. B. L. Calendar**TUESDAY, July 11, 8:00 P. M.**

Seminar: Dr. Floyd Moser: The Differentiation of isolated Rudiments of the *Amblystoma punctatum* Embryo.

Mr. Robert H. Silber: The Production of Duplicata Cruciata and Multiple Heads by Regeneration in *Planaria*.

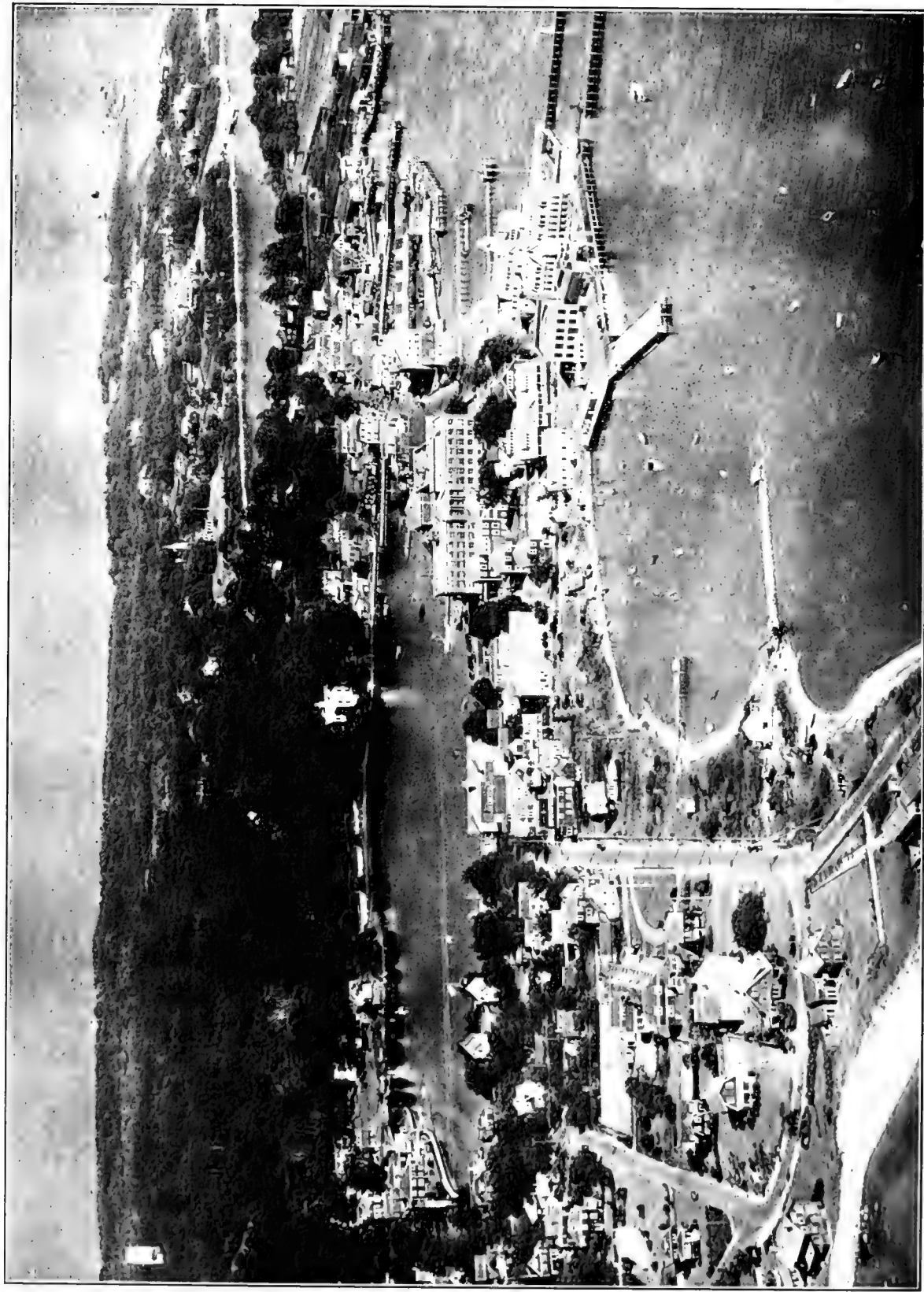
Dr. L. G. Barth: Differentiation of Neural Tubes without Organizer.

FRIDAY, July 14, 8:00 P. M.

Lecture: Dr. Rudolf Höber: Title to be announced later.

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THE MARINE BIOLOGICAL LABORATORIES OF WOODS HOLE

ture change in the origin and evolution of species have grown less and less frequent in the literature on the mechanism of evolution, and less and less positive. In so good a review of the present status of evolutionary theory as Dobzhansky's (1937) *Genetics and the Origin of Species* the words "heat", "temperature" and "climate" do not appear in the index, and no general statement concerning their influence in evolution is even attempted. This interesting omission is due, of course, to the fact that the development of the theory of the gene, the understanding of the interaction between gene and character now called physiological genetics, and the working out of the distribution of gene frequencies in natural populations have all been necessary before the older problems of the mechanism of evolution could even be stated in modern terms. The problem has proved very much more difficult than was imagined in the period following the publication of Darwin's *Origin of Species*. It is a very real achievement that the work of geneticists and ecologists in many countries during the past twenty-five years has now developed the basic principles for an understanding of how evolutionary changes occur in nature. It is possible that now we have reached a point where it is profitable once again to ask how evolutionary change is influenced by environmental agents like heat energy, and to estimate the importance of ubiquitous temperature changes in keeping the process going.

For many years our small group of geneticists at the Amherst laboratory has been interested in the effects of temperature on various genetic phenomena in *Drosophila*, always I think with this question of evolutionary bearings as a secondary problem. While I have been continuously interested, the major share of the investigation has been carried by my students and, especially during the past four years, by my colleague Dr. George Child. Formerly Dr. Philip Ives had an important part in these cooperative investigations and, as a holder of a seven year research fellowship from the college, he has recently returned to our group. I shall confine my report mainly to work done at the Amherst Laboratory even though I am fully aware that it leans heavily on the important work of others like Muller, Wright, Dobzhansky, Timofeef-Ressovsky, Demerec and the Russian investigators for its significance. In their proper setting I believe these *Drosophila* investigations make it possible to indicate the importance

of heat energy and temperature change in evolutionary processes in nature.

In general temperature may influence evolutionary processes in at least three different ways: (1) by affecting character expression, (2) by affecting the mutation process, (3) by acting as a secular agent in such a way as to influence the composition of natural populations. I shall discuss our evidence on each of these points, and attempt to indicate its importance for the problem of evolution. There are doubtless other possibilities which have been omitted.

I begin with section (1), the relation of temperature to the succession of steps in development by which the gene expresses itself as the character. Among those who have concerned themselves with these problems may be mentioned especially Krafka, Harnly, Ludwig, Goldschmidt, Plunkett, and Child. Krafka showed that the number of facets in the bar eye character decreased with an increase in temperature, and Harnly showed that the size of vestigial wings increased. Ludwig demonstrated for the Japanese beetle that each stage in the life cycle has a different temperature coefficient. The more recent work on the temperature effective periods for different mutant characters has shown in general that each is independent of the others, and Child has demonstrated that that holds even for the separate bristles on the body of the fly. These various facts seem most easily interpreted along the lines first suggested by Plunkett, and later developed and extended by Goldschmidt, as the rate theory. According to this concept, development consists of a succession of interacting physiological processes each having its own characteristic rate and temperature coefficient. In the normal individual these interact with each other at the proper time to produce the complete organism, and each interaction has a certain "margin of safety" which allows the normal result even with a certain variation from the optimum in any direction. Abnormal individuals may be expected in normal stocks as a result of temperatures beyond the margin of safety for the particular interaction involved (Goldschmidt's phenocopies). Mutations consist of genetically determined changes either in specific reactions or in the rates of one or another process so that some particular interaction is incomplete. The rate mutations thus are not qualitatively different from the normal, but rather quantitatively so. For this group of mutations especially, heterozygous individuals would more

closely approach the limits of the margin of safety and so might be expected to show greater effects from temperature change than normal stocks, and this is exactly what occurs. Several years ago we ran a careful series of tests to discover the effects of exposure to high temperature (36.5° for 12 hours) at 12 hour intervals from egg to pupa on wild *Drosophila* stock, and on three stocks heterozygous, for several different recessive mutant genes located in one of the three large chromosomes. It seems clear from these results that many—if not most—mutant characters can be made to appear in normal stocks by treatment at some time during development with high temperature. But the same characters appear in larger percentage and over a wider time range if the stocks heated are heterozygous for the genes which produce these characters in homozygous condition. One of our students, Blanc, has recently shown that similar reasoning applies to the pupal period in a detailed investigation of the temperature-effective period of truncate wing. It is significant that pupal age and not total age of the organism must be taken as the standard. In general these and similar data indicate that one of the chief effects of temperature changes in character expression is in the nature of a shift from the recessive to the dominant condition. In wild population, which always carry a certain number of heterozygous mutant genes, the importance for evolution of such changes would be toward a speeding up of the automatic processes of selection. Most mutations are deleterious in their effects and they would tend to be more quickly eliminated by a shift to partial dominance, while the exceptional advantageous mutation would increase in numbers more rapidly as a result of moderate temperature changes in nature.

We now pass to the second group of effects, the relation of temperature to the mutation process. Studies of Muller published in 1928 suggested that *Drosophila* stocks kept at 27° gave a larger number of mutations than those kept at ten degrees lower. A year or so later Goldschmidt brought forward evidence that exposures of *Drosophila* larvae to sub-lethal temperatures for short intervals (37° for 12 hours) resulted in a marked increase in mutations, both visibles and lethals, among their offspring. Thus were introduced the ideas of a general relation of temperature to mutation, and also the induction of mutations by "temperature shocks". This work was followed by extensive investigations of many other geneticists which are still going on. Chief among these have been those of Jollos, of our Amherst group, and of Timofeef-Ressovsky. In spite of some discrepancies, I think it may be said that the results of all these laborious investigations have been to establish the truth of each of the conceptions ori-

ginally suggested, namely: (1) that the frequency of mutation bears a direct relation to the temperature at which the flies are kept, and (2) that temperature shocks cause a fairly marked increase in mutation frequency independent of the length of the exposure. It became evident early in the work that these questions could be settled only by the use of some criterion of what constitutes a mutation which would be independent of the judgment of the individual investigator, and lethal mutations fill that role. We have used for studying the effects of temperature on lethal mutation the well known CIB stock devised by Muller for showing X chromosome lethals, and a similar mating scheme requiring one further generation for the tests to reveal lethals in the large autosomes (chromosomes II and III).

To date we have found the chromosome III results unreliable because of difficulties in eliminating crossing-over and translocations, and so only those involving Chromosomes I and II have been used. Enough data have now been secured to make a summary desirable, and this is shown in Table I.

In general the work of the three groups of investigators here cited appears to establish the two conclusions already stated. The first is that mutation frequency increases with increased temperature in each of the chromosomes. The actual differences are not statistically significant step by step, but the extremes are, and the results within each series are consistent. When the time of development at each temperature is taken into account it appears that mutation follows a typical Van't Hoff curve, and that the temperature coefficient approaches 5. It is interesting to note also that at the lower temperatures the amount of mutation is extremely low, but within the ordinary optimum temperature range of the species, spontaneous mutations occur at constant temperature even when all other minor variables in the natural environment are eliminated. Secondly, the effects of temperature shocks are equally apparent, especially when we include the recent results of the Russian worker Birkina. Short exposures either to low or high temperature alike increase mutation rates, apparently independently of the length of the exposure or the temperature used.

The first implications of these facts for the mechanism of evolution seems plain. Given two identical populations, *A* living at 18° and *B* at 28° , we should expect, other things being equal, that at the end of any given period *B* would not only have gone through more generations, but in *B* at least three times as many mutations per generation would have passed through the sieve of natural selection. In other words the automatic genetic processes in population *B* would

TABLE I.
Relation between frequency of lethal mutations and temperature
(Data of several investigators)

The figures given in each column are: total number of chromosomes tested, number of lethals found, percentage of lethals with the probable error.

Temperature egg to imago (except as noted)	Chromosome I		Chromosome II	
	Buchmann and Timofeef-Ressovsky 1936	Birkinia 1938	Plough and Child 1937-1939	Birkinia 1938
-6° 25-40 minutes larval stage		9430 66 0.69 ±0.050		252 62 2.45 ±0.207
8° 10-15 days			179 0 0.00	
14°	6871 6 0.087 ±0.0227			
18°			197 0 0.00	
Controls 22° 25°	3708 7 0.188 ±0.0227	9695 21 0.22 ±0.032	979 8 0.82 ±0.194	3225 27 0.03 ±0.108
28°	6158 20 0.325 ±0.0481		210 2 0.95 ±0.451	
31°			72 2 2.77 ±1.303	
36.5° - 37° 12-24 hours larval stage	11687 34 0.291 ±0.0330		365 4 1.09 ±0.363	

have proceeded at a much more rapid rate. This is not to deny the widely held conclusion that a small rise in the general mutation rate would have no important effect on the trend of evolution in any population. The same advantageous mutations might occur in population *A* as in population *B*, so that the direction of evolutionary change might be exactly the same in the two populations. But it would still be true that after 1000 years the population at the lower temperature would be only about a third of the way along the same road that *B* had already traveled. It is interesting that this agrees with the contention of the bacteriologist Rahn in a recent paper called "Building stones to a chemistry of evolution." Using admittedly inadequate taxonomic lists he attempts to show that there is markedly greater

diversity of animal and plants species in tropical areas than in temperate zones.

It is more difficult to estimate the significance for evolutionary change of the second fact shown by our studies of mutation frequency, namely the increase produced by temperature shocks. Rapid changes of the order of those found to increase mutation frequency occur in almost any environment. Perhaps they tend to compensate in temperate regions for the higher mutation rate due to the relatively higher average temperature. We suggested some years ago—and the Russian investigator Zuitin has recently renewed the suggestion—that temperature changes might be the causal agent in the basic mutation rate, or genetic variance, in nature. But the demonstration that even under the most constant conditions of tem-

peratures and humidity there is no such thing as a genetically static species indicates that mutability is a fundamental characteristic of the gene, and that mutations are apparently fortuitous chemical rearrangements which like other chemical processes are increased in frequency by heat and apparently by a rapid and extreme shift in temperature.

While the direct relation between mutation frequency and temperature seems to be established, some qualifications must still be applied to the interpretation of the data on temperature shocks, because our results with different stocks are not uniform. In tests of five different stocks made lethal free, 100% differences in the percentage of lethals were found which may be real even though they are not statistically significant. In only two of the four exposed to a temperature shock did the increase in mutation frequency occur. Similar differences in the mutability of different strains have already been noted especially by Demerec for Chromosome I and by other investigators for Chromosome II. It is probable that these differences are to be accounted for, as Demerec suggests, by genetic factors influencing mutability. If this is so, it may be that the temperature does not act in the same way on the modifying genes and so its effect on the genes themselves is masked. So the importance of the

shock effect in evolutionary processes might be modified in special cases.

Another incidental fact demonstrated by Table I is the greater mutability shown by chromosome II as compared with the X chromosome (chromosome I). Chromosome I is shorter than II as shown by oogonial metaphases and salivary smears. In gene number it has been estimated that they compare as 1 to 1.7. In mutability where both chromosomes have been tested in the same stock, it appears that genes are at least three times as likely to mutate in chromosome II, and the ratio of mutability averages 1 to 3.8. The one exception occurs in the case of the Florida stock where our high value for the X chromosome exactly coincides with that of Demerec. It is clear that the mutability genes are acting on chromosome I only. This larger mutation coefficient in the autosome has been interpreted by Muller and by Berg to be due to the fact that males carrying lethal bearing genes are eliminated in every generation, while in the autosomes the lethals may be carried in heterozygous condition for many generations. So sex chromosomes containing genes showing high mutability are selected out much more rapidly, and differences in mutability between chromosomes have arisen.

(To be Concluded)

(Publication of the Directory in this number has made it necessary to postpone the balance of Dr. Plough's article until the following issue.)

NOTE ON THE GAS CONTENT OF THE FLOAT OF PHYSALIA

VIRGINIA SAFFORD

Assistant in Zoology, Swarthmore College

Many Portuguese Men-of-War (*Physalia*) appeared in the waters around Woods Hole in the middle of July, 1938. They attracted a good deal of attention because of the beautiful blue, pink and green coloring of the float and the delicate tentacles (with effective stinging powers) which descended from the float. In size they varied from about 6 inches to over a foot. A gas sample was taken from the float of one specimen on July 19th and analyzed for CO₂ and O₂. This was not done again until August 7th and 16th when specimens had become rare and hard to procure. The

results are tabulated below and may be compared with CO₂ and O₂ content of air. It is suggested that the consistently higher CO₂ and lower O₂ than air may be due to metabolism rather than to active secretion of gas. Further investigation was not made, however, so that the physiological significance of the data cannot be fully appreciated.

Physalia gas analyses were made by Schloesing and Richard in 1896 of gas from specimens in the Atlantic probably off the French coast. They found 1.7 parts CO₂ and 15.1 parts O₂. (T. Schloesing and J. Richard, *Comptes Rendus*, 122, 615, 1896).

TABLE I.

CO₂ and O₂ Content of Physalia Floats and Air

Date	%CO ₂	mm CO ₂	%O ₂	mm O ₂	
July 19, '38	.306	2.27	15.7	117	(After several days in an aquarium)
August 7, '38	.256	1.91	18.7	140	(Freshly brought in)
August 16, '38	.251	1.87	17.5	131	(One day in aquarium)
Air	.031	.23	20.92	156	

EVENING LECTURE SERIES OPENED BY DR. LILLIE

The regular series of Friday evening lectures at the Marine Biological Laboratory was opened on June 30 by Dr. Frank R. Lillie, president of the Corporation, with a message of welcome to investigators and students. A transcript of his remarks, based on shorthand notes, follows:

Ladies and Gentlemen: This is the first general meeting of the fifty-second session of the Marine Biological Laboratory. I wish to take advantage of this occasion, on behalf of the Corporation, to bid welcome to the investigators new and old, and to the students new and not very old—of course—and wish in your earnest work success and enjoyment. And I feel very sure that all will enjoy the opportunities for recreation that this place affords.

Since our last session the Laboratory has suffered serious losses of membership, unusually serious losses: Edmund Beecher Wilson, dean of American zoologists, trustee of this institution practically since its foundation, who died during the year; Charles R. Stockard, the noted anatomist and member of our Corporation and trustee for a great many years, who departed from this life too soon; and Charles R. Crane, for many years President of the Corporation and principal benefactor of the Laboratory for a great many years, whose portrait you see here on the wall, which was presented at a very timely occasion, as it turns out, last year in a celebration that we had for the fiftieth anniversary of the founding of the Laboratory. These were members of the trustees, and among the Corporation. We have two others: Calvin B. Bridges, noted geneticist, who has worked here for many years, and Edwin Linton, who was perhaps the Nestor of Woods Hole, who was here before the Laboratory was founded, and many years after with his wife established the Edwin S. Linton Schol-

arships at Woods Hole for the students of Washington and Jefferson College. These losses among the members of the Corporation should serve to remind us that our freedom and our liberty and our possessions are limited, and that the control of the affairs of the Laboratory is rapidly passing into the hands of younger members, that they will have to bear the responsibilities of the Laboratory in the future, that a change is coming very rapidly over the laboratory as the older members, who for many years gave their devotion to the institution, are very rapidly dying out.

Since we last met we have had the hurricane disaster, which occurred at a time when most of the members of the laboratory had left, and there were thus no casualties among laboratory members. Contributions came forward very generously from the Carnegie Corporation and were adequate to restore the losses suffered, so that today hardly anyone would notice the damages to the laboratory and you will find that it is just as well equipped to forward your research and studies as ever.

Now we are about to hear the first evening lecture of the season. These lectures are a very old institution, having been started by Professor Whitman, the founder of the laboratory, during his first year here, and maintained every year since. These are lectures in which some investigator presents chiefly the results of his own work in a way that is comprehensible to the general fraternity of biologists.

This evening we are to hear from Professor Plough of Amherst on the influence of temperature in evolutionary changes as noted in his studies on *Drosophila*. I take great pleasure in asking Professor Plough to take the platform. Professor Plough. (Applause).

EMBRYOLOGY CLASS NOTES

"I certainly never knew how many parts a microscope has until I greased mine! !" With this discovery by the budding scientists as they laboriously vaselined all metal portions of their 'scopes, the embryology class of 1939 got under way. Eager faces and poised notebooks greeted Dr. Goodrich as he opened the course with a lecture on fish. To those who had never worked with living material, there was much excitement as the fundulus eggs cleaved first in two, then in four, and so on in the orderly progression of multiples of two. Late in the evening one might hear, "Yes, I'll go down town for a cone, but I have to be back in time to see the sixteen-cell stage!" Some even refrained from joining the

general late afternoon exodus to the beach just to watch the gastrula form. After struggling for some time with the circulatory system of the fundulus, the cunner and its polar body formation engrossed the class who craned their necks to look through horizontal 'scopes. Then there was the famous night when one of the few live cunner developed a pronephros under the curious scrutiny of several members of the class who insisted that it was dead just because they couldn't see the heart beating. "It's dead. Watch the tail curl up." "It isn't either, there goes its heart!" "Where?" "Well, I can't see it." However, the pronephros did form, even though the cunner was with the departed the next morning.

A more general observation of nature was made the day the whole class migrated to the fish traps by way of the *Sagitta* and the *Nereis*. A choppy sea and a generous sprinkling of sea water made it all the more fun for those who had never before been out on the ocean.

"I never thought I'd live to bounce a living nucleus!" Such a comment was brought forth after the demonstration by Dr. Duryee of his technique of removing nuclei from living cells and studying their contents by means of vital staining. A true test of steady nerves was made when the members of the class tried to imitate what seemed so easy when accomplished by his experienced fingers. His moving pictures of the effect of ordinary fixatives on tissue and its constitution made us groan to think of the cytology work that we had done previously.

With a timely warning not to let the "side-shows" occupy all of our time, Dr. Ballard introduced us to various beautiful and fascinating forms of coelenterates. Chopping off the heads of tubularia, seems a horrible destruction, but we all felt better when the next day we observed that each stalk was regenerating a head as beautiful as the old one had been.

"Mine looks like a surrealist drawing of humanity under a bowl of sky with a cloud floating around on top!" "Oh, no, it looks much more like a fat lady with a fur collar and one of these crazy things women put on their heads

these days!" And all the time it was only the student's best attempt to draw a squid embryo! Dr. Hamburger directed our inquiry into the nature of this amazing little animal, but even his inspiration and the intricacies of the embryo couldn't compete with the interest of the budding embryologists in the great Louis-Galento fight, for every one crowded around the portable radio that had been brought to the lab for the occasion.

The sight of starfish actually curving their penta-symmetrical bodies about a pole was one of the most interesting to those students fresh from inland schools as Dr. Schotté introduced the portion of the course dealing with echinodermata. As this is being written, the intricacies of the transformation from bilateral to penta-radial symmetry are furrowing the brows of the investigators.

Short respite from such observations was given us by Dr. Packard as he gave a brief history of embryology and of the laboratory.

Although students may be found working in the laboratory at all hours of the day and evening except at meal times, there was considerable consternation at the suggestion that Dr. Goodrich might use a photometer to determine credit for the course in a ratio inversely proportional to the darkness of one's coat of tan!

—Frances Pauls

PROTOZOOLOGY CLASS NOTES

Mustered from Minnesota to the sunny shores of Georgia, 12 students are attending the class in Protozoology of the Marine Biological Laboratory. The course, conducted by Dr. Gary N. Calkins and Dr. George W. Kidder, consists of a series of lectures supplemented by laboratory work designed to give the student an adequate introduction to Protozoology and a substantial background for advanced work in this field.

After a timorous first week of arduous collecting and drawing, the "Protos" as they are loosely called, and they are loosely called, have excysted. Their lusty cries of "*Pork*" bellowed in a stage whisper a trifle louder than the fire horn readily betrays their presence. Working, eating, and dawdling together (Do Protozoologists *really* sleep?) has given the class an organized relationship. Extra-curricular lectures and shindigs are attended in a body.

Work in the laboratory has brought the students into contact with a great variety of interesting unicellular forms. In addition to collecting and culturing material gathered in the vicin-

ity of Woods Hole, the Protos have trudged a beaten path to their wit's end attempting to draw specimens found. Slow moving forms have gained a great popularity with the students who so often seem to come out second best in the pursuit of the rapidly moving bugs. To some, even the slow moving forms present a problem, one student claiming a form under his 'scope had repeatedly tried to stare him down.

Hours have no fears for the bug hunters who haunt the lab with little respect for Morpheus. "Pork" is as likely to be heard after midnight in the vicinity of the lab as it is during the day. The Physiology class beneath have occasionally shown a disinterest in the meat cry, and have listened in amazement at the unbelievably loud stomplings of Charlie, the Colpidium, whose wooden legged ghost often paces the floor.

Sunday the Protos took a holiday for the afternoon and journeyed to Nobska light on a picnic. A pleasant time and sunburn was had by all. With morale high, the followers of elusive, lowly life are plunging into another week of study with high hopes.

—Cecil Reid Reinstein

DEPARTMENT OF PUBLICATIONS

ANIMALS WITHOUT BACKBONES. By Ralph Buchsbaum. The University of Chicago Press. \$5.00 1x + 371.

This beautifully produced, if somewhat costly work, is designed to serve as a textbook for a college course in invertebrate zoölogy, and appears to be one of a series intended to inaugurate a new tradition in such textbooks. It is lavishly illustrated with photographs, many of which are superb; these illustrations should go far to remove the perennial difficulty of the majority of forms studied in the invertebrate laboratory appearing only in an alcoholic and cadaverous state, giving little evidence of their interest and beauty as living animals.

The text of the book will not be accepted by all with such unreserved enthusiasm. A survey of all the invertebrate phyla from the Protozoa to the Protochordata is presented, the great coelomate phyla receiving proportionately less space than their importance would seem to justify. Within limits of space this survey is well informed and up-to-date, though in places marred by a certain lack of definition in detail. The final chapters deal with palaeontology and phylogenetic problems. There is an important digression on the axial gradient theory. Such discussion of the general aspects of morphology is commendable and might be extended.

It is the style rather than the matter of the book to which some exception may be taken. Such a criticism of style is by no means trivial inasmuch as it raises a major set of problems in the theory of scientific education. Not merely are the indispensable feminine nouns given plurals in *s* (*antennas*, but not *flagellums*—to the present reviewer one is not worse than the other), but a considerable effort is made to minimise the number of terms of classical origin. This is not only indicated by the title of the book but in such

chapter headings as "Soft-bodied Animals" and "Spiny-skinned Animals". This supposed simplification gives the book a consciously modern flavour; it suggests that the classical learning of the past may be dispensed with and that the mode of presentation adopted is in harmony with the needs of the day. Scientific terminology, however, has been evolved primarily in the interests of accuracy, technical words being used with greater discretion than the vernacular of everyday living. Such words, therefore, tend to keep their meanings undistorted and undisguised. The fact that they are unfamiliar at the beginning of the study of a subject is an advantage, as they are presented free from previous meanings and emotional associations. The fact that the majority are of Greek or Latin derivation is irrelevant, words derived from Sanskrit would be equally satisfactory. To apologise for their necessity is to apologise for the need for accuracy, even in a chapter heading. There is a good index.

Yale University

G. E. Hutchinson

BOOKS ON THE NEW BOOK SHELF IN THE M. B. L. LIBRARY

Science In Progress. Edited by G. A. Baitsell. Yale.

The Biology of the Cell Surface. Just. Blakiston.

Fundamentals of Experimental Pharmacology. Sollmann and Hanzlick. Stacey.

Crystalline Enzymes. Northrup. Columbia.

Principles of Development. Weiss. Holt.

Cambridge Biological Studies, Form and Causality. Daleq. Cambridge. (Macmillan).

Animals Without Backbones. Buchsbaum. Chicago.

Experimental Physiology. Sharpey and Schafer. Longmans, Green and Co.

M. B. L. TENNIS CLUB

The clay court by the Mess Hall was opened on Tuesday, June 27, and the Colas courts on the following day. The "Mess" court has been regraded and entirely resurfaced, and is now in excellent condition. The Colas courts survived the hurricane without suffering extensive injury, damages being confined to the backstops. The two new clay courts, located near the Breakwater Beach, were almost completely destroyed during the hurricane—principally as a result of the wanderings of the bath house. These courts have been entirely rebuilt and will be opened during the week of July 2. With 3 essentially new clay courts the playing facilities of the Tennis Club are the best in its history.

A series of tournaments is being planned,

starting the latter part of July and terminating around September 1. These will include men's and women's singles and doubles, mixed doubles and children's singles. Everyone is being urged to participate.

Dr. Russell Carpenter of Tufts University, President of the Club, will not be in Woods Hole before August 1. Meanwhile Dr. C. C. Speidel of the University of Virginia is assuming the duties of President. Dr. L. H. Schmidt of the University of Cincinnati, is Secretary-Treasurer. Club memberships may be obtained from Dr. Schmidt in Brick 107 at any time. Membership is primarily for laboratory workers and their families; non-laboratory persons may join for a somewhat higher fee.

—L. H. Schmidt

The Collecting Net

A weekly publication devoted to the scientific work at marine biological laboratories.

Edited by Ware Cattell with the assistance of Boris I. Gorokhoff and Mona Garman.

Entered as second-class matter, July 11, 1935, at the U. S. Post Office at Woods Hole, Massachusetts, under the Act of March 3, 1879, and re-entered, July 23, 1938.

Introducing

DR. VICTOR DESREUX, Research Assistant in Chemistry, University of Ghent, Belgian-American Foundation Fellow.

Dr. Desreux declares that his hobby is traveling, and this statement seems to be borne out by his activities since his reception of a degree of Doctor of Chemistry at Ghent, Belgium, in 1934. Under Professor Swarts, he had studied fluorine compounds as well as surface tension and Raman spectra as applied to organic chemistry. He spent 1935 and 1936 in Paris under a French Government Fellowship at the École Normale Supérieure, where he continued work on Raman spectra and turpenes under the direction of Professor Dupont. Then he traveled to the Netherlands, where he studied biological chemistry under Professor Kogl at the University of Utrecht, concerning himself with the determination of perezome structure and with phyto-hormones.

1937 found him in the United States under the Belgian-American Foundation, conducting research at Harvard University on methylcholanthrene, one of the strongest cancer-producing agents known. He spent the summer of 1938 on an extended tour of the United States and Canada, proceeding as far west as California. (He estimates that he has traveled 20,000 miles in the United States). In the fall of 1938 he undertook research in enzymes at the Rockefeller Institute in Princeton under Dr. Northrop, concentrating upon pepsin. He is continuing the work at the Marine Biological Laboratory this summer.

While Dr. Desreux's plans for this fall are not definite, he will probably return to Europe. He has been particularly impressed with the high degree of organization in American scientific laboratories, which manifest a spirit of coöperation often lacking in European ones.

THE STANFORD SYMPOSIUM ON THE CELL

Five trustees of the Marine Biological Laboratory are among the sixteen biologists taking part in a symposium at Stanford University this week in commemoration of the one-hundredth anniversary of the discovery of the cell theory by Schleiden and Schwann. These biologists, and the titles of their papers are: EDWIN G. CONKLIN, "Cell and Protoplasm Concepts: Historical Account." ROBERT CHAMBERS, "The Microdissection of Living Cells." H. S. JENNINGS, "Chromosomes and Cytoplasm in Protozoa." R. G. HARRISON, "Cellular Differentiation and Internal Environment." L. V. HEILBRUNN, "Protoplasm and Colloids."

Professor Edwin G. Conklin was the subject of an extensive article in the July 3 issue of *Time* in connection with the celebration, and his portrait was reproduced in colors on the front page of the journal. This article described Conklin as declaring the celebration to be a "scientific fraud," and that cells had been fully described as much as 170 years earlier than Schleiden and Schwann's announcement in 1839. The larger part of the article, however, is a description of Dr. Conklin's life and work.

DR. HAROLD H. PLOUGH returned to Amherst College immediately after delivering the lecture last Friday to continue his work upon the genetics of *Drosophila* as influenced by temperature. He will leave Amherst on August 5 to attend the Seventh International Congress of Genetics at Edinburgh, accompanied by Dr. George Child and Dr. Philip Ives. Dr. Plough will present a paper at the congress on his *Drosophila* studies. He is planning to return to the United States early in September.

CURRENTS IN THE HOLE

At the following hours (Daylight Saving Time) the current in the Hole turns to run from Buzzards Bay to Vineyard Sound:

Date	A. M.	P. M.
July 8	9:35	10:04
July 9	10:22	10:56
July 10	11:11	11:53
July 11 .....	.....	12:07
July 12	12:45	1:03
July 13	1:40	1:56
July 14	2:35	2:47

In each case the current changes approximately six hours later and runs from the Sound to the Bay.

ITEMS OF INTEREST

The *Atlantis* sailed on the afternoon of July 5 for a cruise of about ten days to continue making hydrographic sections across the Gulf stream. The work is being directed by Dr. A. H. Woodcock.

DR. RICHARD D. KIMBALL has been appointed instructor in zoology at Johns Hopkins University. During the past year he has been Sterling Fellow at Yale University, engaged in research on the inheritance of mating types in the hypotrichous ciliate *Euplotes*.

DR. WILLIAM R. DURYEE, who has been research associate in biology at Washington Square College of New York University, has been made assistant professor.

DR. A. GLENN RICHARDS, JR., instructor in biology at the College of the City of New York, is resigning on September 1 to accept an appointment in the Department of Zoology at the University of Pennsylvania.

MR. JOHN M. ROBESON has been promoted from an assistant professor to associate professor in the Department of Zoology at Syracuse University.

BERTRAN C. KRIETE, of the University of Cincinnati, who was an investigator at the Marine Biological Laboratory last summer, has been awarded a University Fellowship to continue his work in the Graduate School of Arts and Sciences at New York University.

MISS ETHEL GLANCEY has been appointed tutor in biology at Queens College in New York City. She is completing her graduate work with Dr. Robert Chambers at Washington Square College of New York University.

MR. S. B. YOUNG, who for many years has been technical assistant to Dr. W. J. V. Osterhout of the Rockefeller Institute, left the Institute in March to become associated with the American Instrument Company.

DR. BOLTON DAVIDHEISER has been appointed Bruce Fellow in Zoology at Johns Hopkins University. He is conducting research this summer at the Bureau of Fisheries station at Woods Hole.

PROFESSOR GEORGE E. NICHOLS, head of the Botany Department at Yale University, died in New Haven on June 20 at the age of 57. He was president of the Botanical Society of America.

DR. WILLIAM J. BOWEN, Bruce Fellow in Zoology at Johns Hopkins University, has been appointed instructor in zoology.

The staff and members of the Embryology course are holding their annual picnic today. The picnic of the Physiology course will be held next Wednesday, July 12.

DR. LAWRENCE IRVING left on Sunday for Gaspé, Quebec, to discuss the research of his two Swarthmore students who are stationed at the laboratory of the College of St. Viator. They are making comparative studies of the respiration of salmon in salt and fresh water. Dr. Irving will return on Tuesday.

PROFESSOR J. R. SCHRAMM, professor of botany at the University of Pennsylvania, visited Woods Hole for a few days in June. He and Mrs. Schramm will spend the summer in New Mexico and vicinity.

DR. WALTER S. ROOT, associate professor of physiology at the College of Physicians and Surgeons, visited his family at Woods Hole over the fourth of July weekend. He will work at the college through July and will return to spend the balance of the summer at Woods Hole.

The following papers have been presented in the botany seminars:

June 29: The cyto-nuclear ratio in plant cells, by Vivian Trombetta; Cultivation of embryos of higher plants, by James Murrey. *July 6:* Phytoplankton of the Gulf of Maine, by Lois Lillick; Experimental decomposition of organic matter in the sea, by Norris W. Rakestraw.

Two of the special lectures have already been given before the Embryology class. On June 26 Dr. W. R. Duryee spoke on "The Colloidal Organization of the Egg Nucleus," and on July 5 Dr. Frank R. Lillie discussed "The Feather as a Developmental System." The third lecture in the series is to be given on July 13 by Dr. Mary E. Rawles of the University of Rochester on "Experimental Studies on Pigmentation of Birds."

Dr. Ross G. Harrison, Sterling Professor of Biology at Yale University, was the recipient of the honorary degree of Doctor of Science at the Commencement exercises at Yale on June 21. The citation, which was read by Prof. William Phelps, was as follows:

Ross Granville Harrison—Revered and beloved leader, eminent scholar, selfless and inspiring personality, for the services you have rendered to this university in its laboratories, its schools of the arts, science, medicine—undergraduate and graduate—for your investigations and discoveries, and for the example you have given to American universities as the perfect scientist, Yale honors herself in conferring upon you the degree of Doctor of Science.

ITEMS OF INTEREST

The Woods Hole Choral Club will not hold rehearsals this summer because of the absence of Mr. Ivan T. Gorokhoff, its director, who will spend the summer in Northampton, Mass. The Choral Club, which had been made up largely of members of the Marine Biological Laboratory, was organized in 1926 and had presented concerts annually from 1927 to 1938 under the direction of Mr. Gorokhoff. About thirty members participated in presenting each year's program, which was usually made up of both secular and religious classical music. There is a possibility that the Club may resume its activities again next summer.

MISS NORMA C. POND, daughter of Dr. and Mrs. Samuel E. Pond, will be married this afternoon at the First Congregational Church in Falmouth to J. Stewart Harlow, Jr., of West Falmouth. Dr. Pond is technical director of the Marine Biological Laboratory.

MR. SAMUEL W. CALKINS, son of Dr. and Mrs. Gary N. Calkins, was married on June 7 to Miss Estelle Howe, daughter of Dr. and Mrs. Hubert S. Howe. Mr. G. Nathan Calkins, his brother, an attorney in New York, has chartered a plane to use in visiting Woods Hole on weekends. He will spend the next month here with his parents.

MISS ELIZABETH MAST and MISS AMICIA MELLAND are taking an automobile trip to California. They are camping out much of the time and visiting the major biological stations and national parks along the way. Miss Melland, who has completed her work with the Carnegie Institution, will return to England in August. Miss Mast will come to Woods Hole about the middle of August. Miss Margaret Mast, her sister, is completing work for her master's degree in political science at Johns Hopkins University and plans to come to Woods Hole later in the summer.

BIOLOGICAL EXPLORATION IN THE PACIFIC OCEAN

(Continued from page 1)

all-steel Diesel cruiser, 195 feet in length, with a cruising speed of 13 knots and a radius of 10,000 miles. She carries aboard supplies for thirty men for three months and is equipped with the latest navigational devices, including a sonic depth finder, radio beacon detector, and gyroscopic compass. On her bow she carries a dredging winch with 7,000 feet of half-inch steel cable enabling her to haul a dredge at a depth of half a mile. Additional gear includes a Sigsbee sounding machine for bottom and water sampling, two photographic darkrooms, and a laboratory for the preservation of biological material. A fleet of auxiliary craft including two 23-foot launches, one of which is equipped as a dredge boat, enables scientists to operate within a radius of several miles from the *Velero's* anchorage or base of operations.

The color film shown at marine biological laboratories was based upon the expeditions of 1936 and 1937 to the Gulf of California and of 1938 to the Bird islands of Peru. From the field of marine biology the film digresses at two points to show interesting sequences of the Seri Indians of Tiburon island, Mexico, and the Quechua Indians of the Andes of Ecuador. The remainder of the picture is concerned with the collection and preservation of the thousands of specimens which have been brought back alive to the San Diego Zoological Society or in a state of preservation to the Allan Hancock Foundation of the University of Southern California.

A remarkable series of echinoderms from the

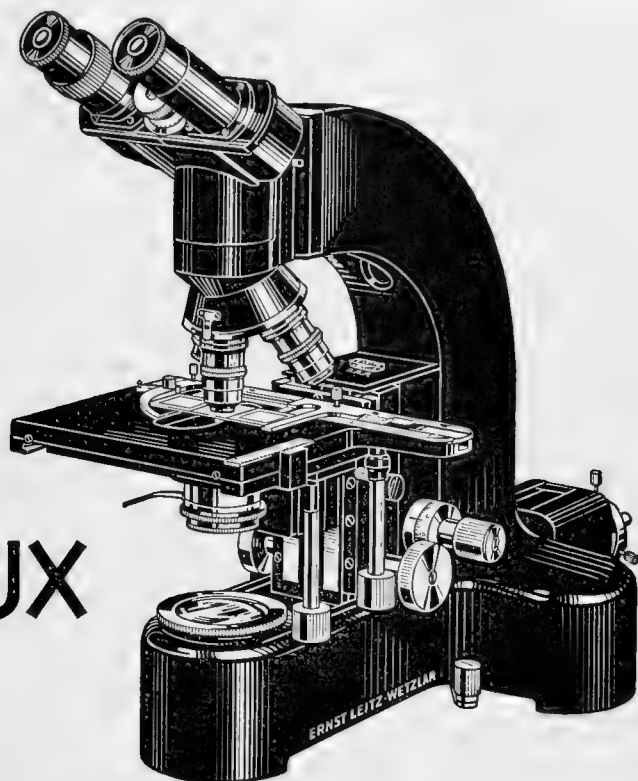
Gulf of California opens the marine life sequence, followed by views of oceanic birds which frequent the islands of the west coast of Mexico, including the frigate bird or man-of-war with a wing span of six and a half feet. Next comes a dredging scene in which the rare walking fish *Antennarius* is brought to the surface from a depth of half a mile. In the Galapagos islands we make the acquaintance of the rare Galapagos fur seal, once thought to be extinct, and the land iguana of South Seymour island. In the Bird islands of Peru the most interesting industry in the world based upon conservation of bird life is shown, featuring four common guano-producing birds—the guanaye, or white-breasted cormorant, the alcatraz, or pelican, and two species of boobies, the camenay and piquero. At the bays of San Juan and San Nicholas the condors of the Andes soar above rookeries of breeding sea lions.

The party returns to San Diego where elephant seals of Guadalupe island and penguins of the Humbolt current are deposited safely in the zoological gardens and university laboratories where scientists and artists prepare the material for exhibition and publication.

(This article is based upon a motion picture and lecture given at the Marine Biological Laboratory on June 23. Mr. John S. Garth has been a member of each of the eight Allan Hancock expeditions as the representative of the Department of Zoology of the University of Southern California in Los Angeles, and is about to continue his studies on crustacea at the U. S. National Museum in Washington, D. C.)

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This third edition of the "Laboratory Directions" has been fully revised in the light of the authors' experience in the University of Missouri, and that of teachers in other institutions whose suggestions have been incorporated. Its well-known value as a teaching aid has been increased by an extension of the work in vertebrate embryology, and the outlining of such experiments in the genetics of *Drosophila* as are feasible for an introductory course. The new edition of the "Laboratory Directions" has been designed to accompany the recently published third edition of Curtis and Guthrie's "Textbook of General Zoology", or any other textbook of comparable scope.

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By SAMUEL EDDY, *Associate Professor of Zoology*, CLARENCE P. OLIVER, *Assistant Professor of Zoology*, and JOHN P. TURNER, *Assistant Professor of Zoology*; all at the University of Minnesota.

A manual of studies of the shark, *Necturus*, and the cat, planned to accompany a book of the type of Adams' "Introduction to the Vertebrates," or any other of comparable scope. Supplemented by a set of outline drawings.

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This laboratory manual presents basic exercises for a first course in bacteriology offered to students with varied pre-professional objectives. The careful selection of the exercises and their logical sequence make for a well-balanced laboratory guide. Activities of microorganisms are stressed, as well as their relations to the various applied phases of bacteriology. There are included a number of discussions introducing some of the major aspects of microbiology. References are given for each exercise. The manual is designed to complement the regularly adopted textbook in introductory courses. It is particularly notable for its flexibility and adaptability to varying conditions of laboratory instruction.

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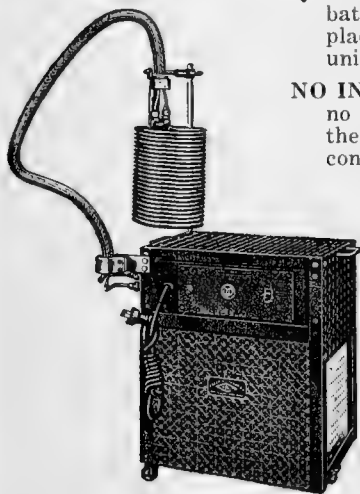
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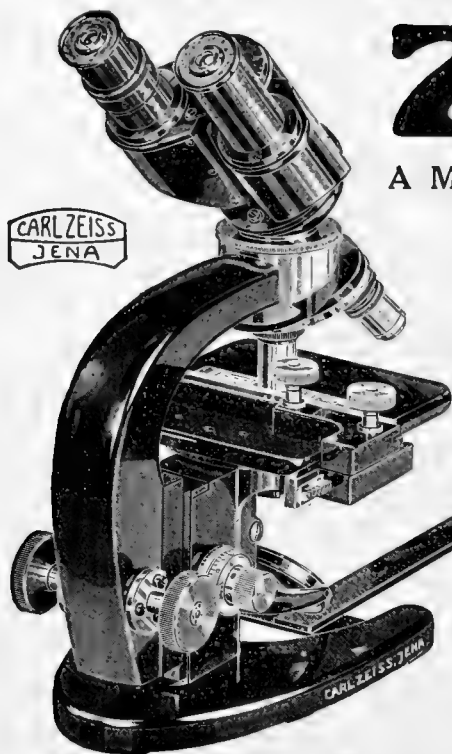
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MARINE BIOLOGICAL LABORATORY

THE STAFF

Packard, C. assoc. director. asst. prof. zool. Inst. Cancer Research, Columbia.

ZOOLOGY

Investigation

Calkins, G. N. prof. proto. Columbia.
 Conklin, E. G. prof. zool. Princeton.
 Grave, C. prof. zool. Washington.
 Jennings, H. S. prof. zool. Hopkins.
 Lillie, F. R. prof. emb. emeritus Chicago.
 McClung, C. E. prof. zool. Pennsylvania.
 Mast, S. O. prof. zool. Hopkins.
 Morgan, T. H. dir. biol. lab. California Tech.
 Parker, G. H. prof. zool. Harvard.
 Woodruff, L. L. prof. protozool. Yale.

Instruction

Bissonnette, T. H. prof. biol. Trinity. in charge.
 Crowell, P. S., Jr. instr. zool. Miami.
 Hahnert, W. F. assoc. prof. zool. Ohio Wesleyan.
 Kille, F. R. asst. prof. biol. Swarthmore.
 Lucas, A. M. assoc. prof. zool. Iowa State.
 Matthews, S. A. asst. prof. biol. Williams.
 Mattox, N. T. instr. zool. Miami.
 Rankin, J. S., Jr. instr. biol. Amherst.
 Waterman, A. J. asst. prof. biol. Williams.

PROTOZOOLOGY

Investigation (See Zoology)

Instruction

Calkins, G. N. prof. proto. Columbia. in charge.
 Dewey, Virginia asst. zool. Vassar.
 Kidder, G. W. asst. prof. biol. Brown.

EMBRYOLOGY

Investigation (See Zoology)

Instruction

Ballard, W. W. asst. prof. biol. & anat. Dartmouth.
 Costello, D. P. prof. zool. North Carolina.
 Goodrich, H. B. prof. biol. Wesleyan. in charge.
 Hamburger, V. asst. prof. zool. Washington.
 Schotté, O. assoc. prof. biol. Amherst.

PHYSIOLOGY

Investigation

Amberson, W. R. prof. phys. Maryland Med.
 Bradley, H. C. prof. phys. chem. Wisconsin.
 Garrey, W. E. prof. phys. Vanderbilt.
 Jacobs, M. H. prof. phys. Pennsylvania.
 Lillie, R. S. prof. gen. phys. Chicago.
 Matthews, A. P. prof. biochem. Cincinnati.

Instruction

Chambers, R. prof. biol. New York.
 Fisher, K. C. asst. prof. exper. biol. Toronto.
 Höber, R. visiting prof. phys. Pennsylvania.
 Irving, L. prof. biol. Swarthmore. in charge.
 Kopac, M. J. asst. prof. biol. New York.
 Prosser, C. L. asst. prof. phys. Clark.
 Shannon, J. A. asst. prof. phys. New York Med.
 Sichel, F. J. M. instr. phys. Vermont Med.

BOTANY

Investigation

Brooks, S. C. prof. zool. California.
 Duggar, B. M. prof. phys. & econ. bot. Wisconsin.
 Goddard, D. R. asst. prof. bot. Rochester.
 Sinnott, E. W. prof. bot. Barnard.

Instruction

Prescott, G. W. assoc. prof. biol. Albion.
 Runk, B. F. D. res. fel. bot. Virginia.
 Taylor, W. R. prof. bot. Michigan. in charge.

INVESTIGATORS

Abell, R. G. instr. anat. Pennsylvania Med. Br 117.
 K 7.
 Abramowitz, A. A. res. asst. phys. Harvard. Br 122.
 Algire, G. H. res. fel. anat. Maryland Med. Rock 3.
 Allee, W. C. prof. zool. Chicago. Br 332. A 101.
 Alley, Armine dem. emb. McGill. Br 317. WD.
 Alsop, F. W. res. asst. phys. Pennsylvania. Br 220.
 Amberson, W. R. prof. phys. Maryland Med. Br 109.
 Andersch, Marie assoc. prof. biochem. Womans Med. Pennsylvania. Br 313.
 Anderson, R. S. biophysicist Memorial Hospital (N. Y. C.). Br 343.
 Angell, Nancy grad. zool. Bryn Mawr. Br 339. H 3.
 Angerer, C. A. instr. zool. Pennsylvania. Br 111.
 Arena, J. F. de la assoc. prof. biol. Havana. Br 330.
 D 112.
 Armstrong, C. W. J. dem. biol. Toronto. OM 1. Ka 23.
 Auringer, J. grad. phys. Columbia. Br 122. Ka 1.
 Badger, Elizabeth A. res. asst. biochem. Cincinnati. Br 341. WE.
 Bailey, K. (London). Rock. fel. Harvard Med. Br 108.
 Baker, L. A. lab. asst. biochem. Lilly Res. Labs. Br 319.
 Baker, R. F. res. asst. phys. Columbia. Br 114.
 Ball, E. G. assoc. phys. chem. Hopkins Med. Br 110.
 D 311.
 Ballard, W. W. asst. prof. zool. Dartmouth. OM 40.
 D 101.
 Ballentine, R. grad. phys. Princeton. Br 231.

- Barth, L. G. asst. prof. zool. Columbia. Br 228.
 Beams, H. W. assoc. prof. zool. State U Iowa. Br 125. D 214.
 Beck, L. V. instr. phys. Hahnemann Med. Br 110.
 Belda, W. H. grad. zool. Hopkins. OM 43.
 Bender, J. C. lab. asst. zool. Swarthmore. OM 29.
 Bissonnette, T. H. prof. biol. Trinity (Conn.). OM 28. D 108-109.
 Bloch, R. res. asst. bot. Columbia. Br 318.
 Boche, R. D. res. asst. emb. Carnegie Inst. (Baltimore). Br 312.
 Boell, E. J. instr. zool. Yale. Br 323.
 Botsford, E. Frances asst. prof. zool. Connecticut. L 22.
 Bowen, W. J. Bruce fel. Hopkins. Br 329.
 Brill, E. grad. zool. Harvard. Br 217.
 Briscoe, Priscilla M. res. asst. phys. Pennsylvania. Br 313.
 Bronfenbrenner, J. prof. bact. Washington Med. (St. Louis). Br 234.
 Brown, D. asst. prof. phys. New York Med. Br 321.
 Brown, F. A. asst. prof. zool. Northwestern. Br 225.
 Brown, M. G. res. assoc. zool. Washington (St. Louis). OM 39. D 318.
 Brownell, Katherine A. res. asst. phys. Ohio State. Br 303. D 106.
 Buck, J. B. res. asst. emb. Carnegie Inst. (Baltimore). Br 312. Dr 6.
 Burnett, J. M. grad. biol. Washington (St. Louis). Br 234.
 Cable, R. M. assoc. prof. parasit. Purdue. Br 115. D 105.
 Calabrisi, P. fel. anat. George Washington. OM 46.
 Calkins, G. N. prof. proto. Columbia. Br 331.
 Campbell, J. B. S. res. asst. phys. Pennsylvania Med. Br 205.
 Cannan, R. K. prof. chem. New York Med. Br 328. (Aug. 1).
 Carpenter, R. L. prof. zool. Tufts. Br 106. A 201. (Aug. 1).
 Cecil, S. asst. biochem. Vanderbilt Med. Br 122D.
 Chambers, R. res. prof. biol. New York Br 328. (Aug. 1).
 Chase, A. M. res. assoc. phys. Princeton. Br 113. (Aug. 1).
 Cheney, R. H. prof. biol. Long Island. Br 118. A 302.
 Churney, L. instr. zool. Pennsylvania. Br 221.
 Claff, C. L. res. assoc. biol. Brown. OM 38. A 208-209.
 Clark, E. R. prof. anat. Pennsylvania. Br 117.
 Cleave, C. D. van instr. anat. Cornell Med. Br 204.
 Clement, A. C. asst. prof. biol. Charleston. Br 217. D 110.
 Clowes, G. H. A. dir. Lilly Res. Labs. Br 328.
 Clutton, R. F. grad. phys. Columbia Med. Br 122A.
 Cole, K. S. assoc. prof. phys. Columbia. Br 114.
 Colwin, A. L. instr. zool. New York. OM 45.
 Copeland, E. asst. biol. Harvard. OM 41.
 Copeland, M. prof. biol. Bowdoin. Br 340.
 Cornman, I. teaching fel. biol. New York. Br 321. K 6.
 Costello, D. P. asst. prof. zool. North Carolina. Br 123. D 204.
 Costello, Helen M. fel. zool. North Carolina. Br 123. D 204.
 Crowell, P. S., Jr. instr. zool. Miami. OM 25. D 207.
 Curtis, H. J. Rock. fel. Hopkins Med. Br 114.
 Curtis, W. C. prof. zool. Missouri. Br 335. (Aug. 1).
 Dach, H. von. res. scholar. Ohio State. OM 9. Dr 5.
 Denstedt, O. F. lect. biochem. McGill. Br 233.
 Desreux, V. (Ghent). fel. physiol. chem. Rockefeller Inst. (Princeton). Br 206. D 216.
 Dewey, Virginia C. asst. phys. Vassar. OM 22. D 309.
 Dieter, C. D. prof. biol. Washington & Jefferson. L 21. D 317.
 Donnellon, J. A. grad. zool. Pennsylvania. OM Base.
 Dowding, Grace L. res. asst. Maryland Med. Rock 6.
 Dowling, Delphine L. asst. bot. Vassar. Bot 1. D 309.
 DuBois, E. F. prof. med. Cornell Med. Br 301.
 Duggar, B. M. prof. plant phys. Wisconsin. Br 339. A 106. (Aug. 1).
 Dumm, Mary E. grad. asst. phys. Bryn Mawr. Br 339. H 8.
 Duryee, W. R. asst. prof. biol. New York. Br 342. D 314.
 Dustin, P. (Brussels). res. fel. Harvard. Br 324. A 105.
 Dziemian, A. J. grad. phys. Princeton. Br 231. Dr 2.
 Edds, M. V. asst. biol. Amherst. Br 317.
 Ederstrom, H. E. asst. zool. Northwestern. Br 225. Ka 1.
 Elftman, H. asst. prof. zool. Columbia. Br 315.
 Erlanger, Margaret instr. phys. West Virginia. Br 311.
 Evans, T. C. assoc. radiol. State U. Iowa. Br 125.
 Ferry, J. D. fel. phys. chem. Harvard Med. Br 108.
 Figge, F. H. J. assoc. prof. anat. Maryland Med. Br 336.
 Finkel, A. J. res. asst. zool. Chicago. Br 332.
 Fisher, K. C. asst. prof. expt. biol. Toronto. OM 4. D 214.
 Frisch, J. A. prof. biol. Canisius (Buffalo). OM 43.
 Fry, H. J. visiting invest. cytol. Cornell Med. OM Base.
 Furth, J. assoc. prof. path. Cornell Med. Br 335. A 108-109.
 Garrey, W. E. prof. phys. Vanderbilt Med. Br 215.
 Geldard, F. A. prof. psych. Virginia. L 29. A 108-109. (Aug. 1).
 Genter, T. S. asst. phys. Cincinnati. Br 107.
 Gettemans, J. F. asst. Rockefeller Inst. (Princeton). Br 208.
 Gilbert, J. G. grad. zool. Cincinnati. Br 340.
 Goddard, D. R. asst. prof. bot. Rochester. Br 322.
 Gold, S. M. Pennsylvania. OM Base.
 Goodrich, H. B. prof. biol. Wesleyan. Br 210. D 210.
 Grand, C. G. res. assoc. New York. Br 342.
 Grave, C. prof. zool. Washington (St. Louis). Br 327.
 Grave, C., II asst. zool. Washington (St. Louis) Br 327.
 Gray, P. assoc. prof. biol. Pittsburgh. Rock 7.
 Gustafson, A. H. asst. prof. bot. Williams. Bot 1f.
 Guttman, Rita tutor biol. Brooklyn. Br 114.
 Hadley, C. E. assoc. prof. biol. Montclair State Teachers'. (Aug. 15).
 Haff, R. M. resident physician. Cornell. Br 315.
 Hairston, N. G. asst. zool. North Carolina. Br 217.
 Hall, T. S. grad. zool. Yale. L 34.
 Hamburger, V. assoc. prof. zool. Washington (St. Louis). OM 33.
 Harris, D. L. instr. zool. Pennsylvania. Br 221.
 Hartman, F. A. prof. phys. Ohio State. Br 303. D 218.
 Harvey, E. N. prof. phys. Princeton. Br 116.
 Harvey, Ethel B. invest. zool. Princeton. Br 116.
 Hayashi, T. grad. phys. Pennsylvania. OM Base.
 Haywood, Charlotte assoc. prof. phys. Mount Holyoke. Br 218. A 206.
 Heilbrunn, L. V. assoc. prof. zool. Pennsylvania. Br 220. (August).
 Henshaw, P. S. res. fel. National Cancer Inst. Br 344. D 102.
 Herget, C. M. res. fel. Russell Sage Inst. Path. Br 334. A 107.

- Heuverswyn, J. D. Van fel. anat. Yale Med. Br 324. D 308.
- Hickson, Anna K. res. chem. Lilly Res. Labs. Br 319.
- Hinchey, M. Catherine instr. biol. Temple. Br 214. A307.
- Höber, Josephine res. asst. phys. Pennsylvania. Br 313. D 302.
- Höber, R. prof. phys. Pennsylvania. Br 313. D 302.
- Hobson, L. B. grad. asst. zool. Cincinnati. Br 340.
- Hopkins, D. L. prof. zool. Mundelein (Chicago). Bot 5.
- Horn, E. C. grad. zool. Princeton. OM Base. Ka 3.
- Hunter, Laura N. asst. prof. biol. Pennsylvania Women. OM 45. W E.
- Hutchens, J. lab. asst. Lilly Res. Labs. Br 333.
- Idoine, L. S. asst. biol. Toledo. Br 315. K 9.
- Irving, L. prof. biol. Swarthmore. OM 2. D 301.
- Jacobs, M. H. prof. phys. Pennsylvania. Br 205.
- Jenkins, G. B. prof. anat. George Washington. OM 46.
- Johlin, J. M. assoc. prof. biochem. Vanderbilt Med. Br 122D.
- Jones, E. R., Jr. prof. biol. William & Mary (Norfolk). Br 310. D 310.
- Kaliss, N. res. asst. zool. Pennsylvania. Rock 2.
- Katzin, L. I. res. fel. zool. California. Br 217i.
- Kaylor, C. T. instr. anat. Syracuse Med. Br 226.
- Keefe, E. L. res. asst. zool. Washington (St. Louis). OM 39.
- Keil, Elsa M. asst. prof. zool. N. J. Col. Women. OM 4. K 8.
- Kidder, G. W. asst. prof. biol. Brown. OM 21. D 208-209.
- Kille, F. R. asst. prof. zool. Swarthmore. OM 29. A 203.
- Kindred, J. E. prof. anat. Virginia. Br 106. (Aug. 1). D 304-305.
- Kitching, J. A. res. fel. biol. Princeton. Br 222. D 201.
- Kleinholz, L. H. indep. invest. Harvard. Br 213.
- Knowlton, F. P. prof. phys. Syracuse Med. Br 226.
- Kobler, J. S. lab. asst. biol. Amherst. Br 317.
- Kopac, M. J. asst. prof. biol. New York. Br 328. D 213.
- Krahl, M. E. res. chem. Lilly Res. Labs. Br 333. A 301.
- Lancefield, D. E. assoc. prof. biol. Queens (N. Y.). Br 126.
- Lee, L. grad. phys. Rochester Med. OM Base.
- Lillie, F. R. prof. emb. Chicago. Br 101.
- Lillie, R. S. prof. phys. Chicago. Br 326.
- Loeb, L. prof. path. Washington Med. (St. Louis). L 28.
- Lucas, A. M. assoc. prof. zool. Iowa State. Br 223. A 202.
- Lucas, Miriam S. Iowa State. Br 223. A 202.
- Lucké, B. prof. path. Pennsylvania. Br 311.
- Ludwig, F. W. grad. zool. Pennsylvania. OM Base.
- Lynn, W. G. instr. zool. Hopkins. Br 217g.
- Mapp, F. E. grad. zool. Atlanta. L 33.
- DeMarinis, F. grad. asst. zool. Western Reserve. Br 111.
- Marsland, D. A. asst. prof. biol. New York. Br 321.
- Martin, Rosemary D. C. asst. phys. Toronto. OM 4. D 306.
- Martin, W. E. asst. prof. zool. DePauw. OM31.
- Mast, S. O. prof. zool. Hopkins. Br 329.
- Mathews, A. P. prof. biochem. Cincinnati. Br 341.
- Mathews, S. A. asst. prof. biol. Williams. OM 27.
- Mattox, N. T. instr. zool. Miami. (July 20).
- Mavor, J. W. prof. biol. Union. Br 315. (August).
- Mayo, Mercedes grad. asst. biol. Havana (Cuba). Br 330. D 112.
- Menkin, V. instr. path. Harvard Med. L 27.
- Merry, J. Cole fel. bot. Michigan. Br 322.
- Meyerhof, Bettina Swarthmore. Br 313. W B.
- Milford, J. J. Jr. grad. asst. biol. New York. Br 232.
- Miller, Ruth N. assoc. prof. anat. Woman's Med. (Pa.). Br 217e.
- Molter, J. A. instr. biol. Notre Dame. OM Base.
- Moore, Betty C. grad. zool. Columbia. Br 314.
- Moore, J. A. tutor biol. Brooklyn. Br 314.
- Morgan, T. H. prof. biol. California Inst. Tech. Br 320.
- Morgan, Lilian Br 320.
- Morrill, C. V. assoc. prof. anat. Cornell Med. Br 301.
- Moser, F. res. fel. zool. Yale. Br 222. D 205.
- Nabrit, S. M. prof. biol. Atlanta. L 33. A 104.
- Nace, P. grad. Columbia (Mo.). Bot 6.
- Navez, A. E. phys. Milton Academy (Milton, Mass.). Br 309.
- Netsky, M. res. asst. Pennsylvania Med. Br 205. Dr 9.
- Neufeld, A. H. lect. biochem. McGill. Br 233.
- Nonidez, J. F. prof. anat. Cornell Med. Br 334.
- Norris, C. H. grad. biol. Princeton. Br 127B. Dr 8.
- Northrop, J. H. mem. Rockefeller Inst. (Princeton). Br 209.
- Novikoff, A. B. tutor. Brooklyn. Bot 1.
- O'Brien, J. P. grad. zool. Hopkins. Bot 1.
- Olson, M. instr. zool. Minnesota. Br 111.
- Ormsbee, R. A. asst. biol. Brown. OM 34.
- Orr, P. R. asst. prof. biol. Brooklyn. L 31.
- Osborn, C. M. Parker fel. biol. Harvard. Br 213.
- Oster, R. H. asst. prof. phys. Maryland Med. Br 336. (August 1).
- Packard, C. asst. prof. zool. Columbia. Br 101.
- Papandrea, D. A. Albany Med. Br 122.
- Parker, G. H. prof. zool. Harvard. Br 213. A 308-309.
- Parmenter, C. L. assoc. prof. zool. Pennsylvania. Br 219. A 303.
- Parpart, A. K. asst. prof. phys. Princeton. Br 231.
- Pease, D. C. res. asst. biol. Princeton. Br 127.
- Pemberton, F. A., Jr. Harvard. Br 317.
- Perrot, M. asst. exper. zool. Geneva (Switzerland). Br 217.
- Philips, F. S. teaching asst. biol. Rochester. Br 322. K 7.
- Pirenne, M. H. grad. fel. phys. Princeton. Br 107.
- Porter, K. R. Nat. Res. fel. zool. Princeton. L 32. D 217.
- Prescott, G. W. assoc. prof. biol. Albion (Mich.). Bot 23. D 111.
- Prosser, C. L. assoc. prof. phys. Clark. OM 3. D 214.
- Rankin, J. S. instr. biol. Amherst. OM 24. Dr 10.
- Ricca, R. A. Pennsylvania Med. Br 311.
- Root, R. W. asst. prof. biol. C.C.N.Y. OM 1.
- Rose, S. M. teaching asst. zool. Columbia. Br 314.
- Rowland, C. R. grad. zool. Columbia. Br 314. Dr 5.
- Ruebush, T. K. instr. zool. Yale. L 26.
- Rugh, R. assoc. prof. zool. New York. OM 44.
- Runk, B. F. C. res. fel. bot. Virginia. Bot 26. K 14.
- Russell, Alice M. instr. zool. Pennsylvania. Br 217d.
- Rynbergen, Henderica J. instr. phys. & chem. Cornell Med. Br 217i. (July 31).
- Safford, Virginia asst. zool. Swarthmore. OM 2.
- Sandow, A. asst. prof. biol. New York. Br 110. (July 25).
- Sayles, L. P. asst. prof. biol. C.C.N.Y. Bot 4. D 304-305.
- Schaeffer, A. A. prof. biol. Temple. Br 214. D 313.
- Schaeffer, Olive res. asst. Br 214.

- Scharrer, Berta indep. invest. Rock. Inst. Br 207
 Scharrer, E. fel. Rock. Inst. Br 207.
 Schmidt, Ida G. asst. prof. anat. Cincinnati Med. Br 107.
 Schmidt, L. H. instr. biochem. Cincinnati Med. Br 107.
 Schotté, O. E. assoc. prof. biol. Amherst. Br 317 and 304.
 Scudamore, H. H. asst. zool. Northwestern. Br 225. Dr 2.
 Sevag, M. G. assoc. bact. Pennsylvania Med. L. 25.
 Shannon, J. A. asst. prof. phys. New York Med. OM 3. A 201.
 Shapiro, H. res. assoc. phys. Clark. Br 110.
 Shaw, Myrtle senior bact. N. Y. State Dept. Health. Br 122B. D 303.
 Sichel, F. J. M. instr. phys. Vermont Med. OM 4. K 8.
 Silber, R. H. fel. zool. Washington (St. Louis). Br 310.
 Sinnott, E. W. prof. bot. Columbia. Br 318.
 Slifer, Eleanor H. asst. prof. zool. State U. Iowa. Br 217a. D 203.
 Smith, C. C. asst. biochem. Cincinnati. Br 3. Dr Attic.
 Smith, D. C. assoc. prof. phys. Maryland Med. Br 336. D 301. (Aug. 1).
 Smith, J. A. asst. zool. Hopkins. Br 5.
 Smith, M. E. Hopkins Med. Br 224.
 Snedecor, J. grad. zool. Iowa State. Br 223.
 Solberg, A. N. asst. prof. biol. Toledo. Br 315. (Aug. 1).
 Sommer, J. H. Columbia. Br 228. Dr 2.
 Speidel, C. C. prof. anat. Virginia. Br 106. D 315.
 Steinbach, H. B. asst. prof. zool. Columbia. Br 228.
 Steinberg, A. G. teaching asst. zool. Columbia. Br 314.
 Stern, K. G. asst. prof. physiol. chem. Yale Med. L 24.
 Stokey, Alma G. prof. bot. Mt. Holyoke. Bot 1.
 Sturdivant, H. P. prof. biol. Union. Br 217f. (Aug. 1).
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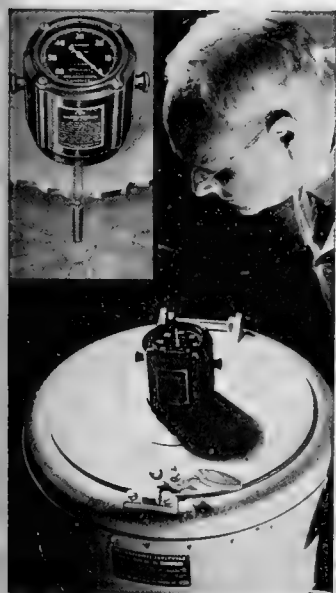
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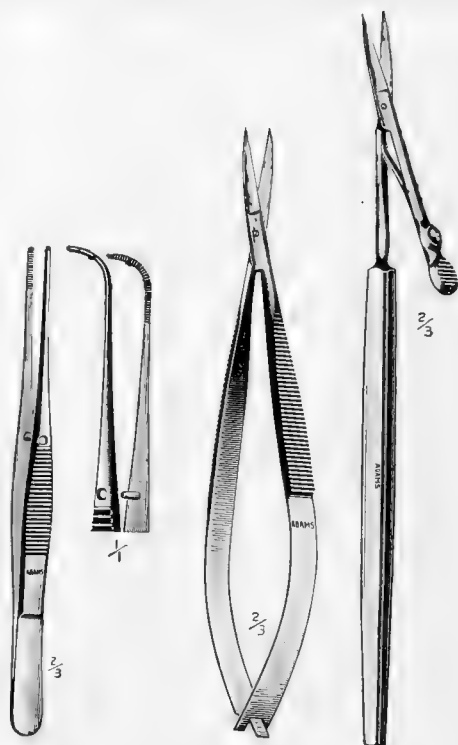
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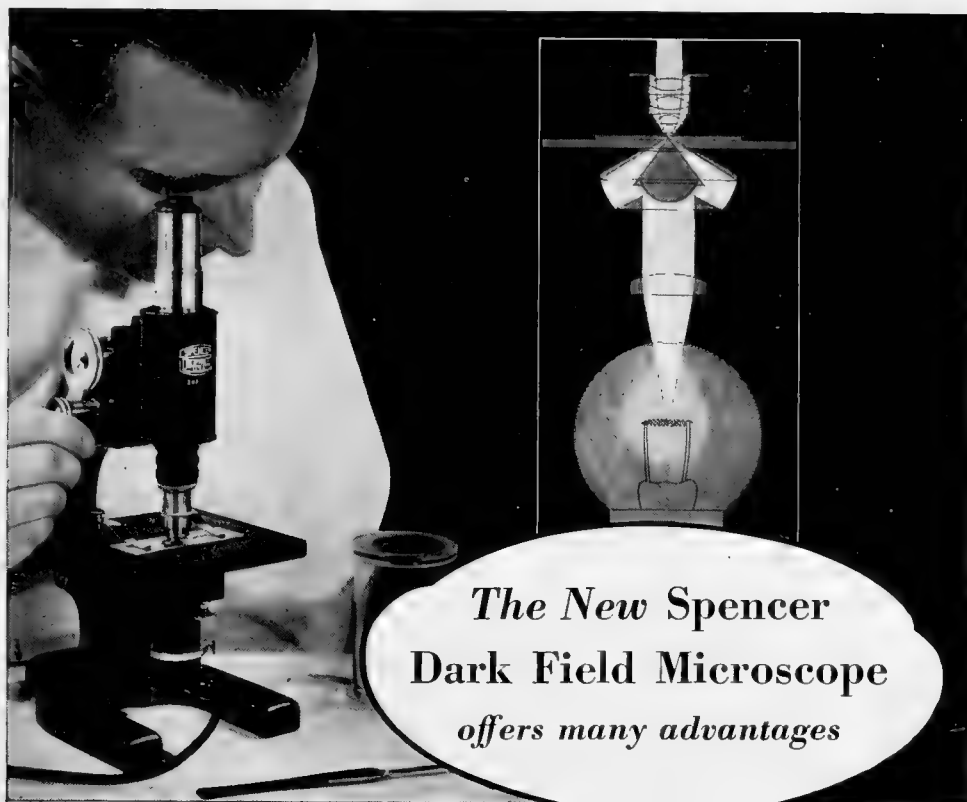
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SATURDAY, JULY 15, 1939

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RECENT CRUISES OF THE "ATLANTIS"

COLUMBUS O'D. ISELIN

*Assistant Professor of Oceanography,
Harvard University*

Towards the end of last September the *Atlantis* sailed for Bermuda. On the outward voyage she occupied the routine line of stations which are being used to determine the long period variations in the strength of the Gulf Stream. Then for about two weeks she worked near Bermuda in co-operation with the *Culver*, the 80-foot ketch which the Royal Society has provided to help out with the Gulf Stream investigations. On the return voyage, late in October, the regular hydrographic stations on the Montauk Point-Bermuda line were reoccupied.

November and part of December were devoted to a much needed overhaul of the hull and machinery. In particular, a large part of the ballast was removed and much of the inside skin of the ship was cleaned off and repainted. By the first of January the *Atlantis* was ready for a long cruise southward.

The scientific party (Continued on page 45)

POLYPLOIDY IN AMPHIBIANS

DR. G. FANKHAUSER

*Associate Professor of Biology,
Princeton University*

Polyploidy was first discovered in plants over thirty years ago. Numerous investigations which soon followed brought out a peculiar difference that exists between the plant and animal kingdoms in this respect. While polyploidy is rare in animals, it is rather common among plants. A Swedish geneticist recently estimated that over 50% of all flowering plants are members of polyploid series. This means that the chromosome numbers found in related species and races frequently are multiples of a common basic number.

Among animals, the known cases of polyploidy fall into three categories:

(1) In a few species of invertebrates, polyploid races occur in nature. In some parts of Europe, a land isopod, *Trichoniscus*, has two forms, one diploid, the other triploid. In the brine shrimp, *Artemia salina*, a tetraploid race occurs. Both these polyploid races reproduce by parthenogenesis, without any reduction of the

M. B. E. Calendar

TUESDAY, July 18, 8:00 P. M.

Seminar: Dr. Kenneth C. Fisher:
"The effect of substrate concentration on the cyanide sensitivity of the oxygen consumption of yeast."

Mr. C. W. J. Armstrong: "A comparison of cyanide and azide as inhibitors of cell respiration."

Dr. Laurence Irving: "Relation of blood to respiratory ability of fresh water fish."

FRIDAY, July 21, 8:00 P. M.

Lecture: Dr. T. M. Sonneborn:
"Sexuality and related problems in *Paramecium*."

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Photograph by M. Schalk

"ATLANTIS" SETTING SAIL OFF MARTHA'S VINEYARD

The research and exploration ketch of the Woods Hole Oceanographic Institution which left on July 5 for the Gulf Stream.

chromosome number during the maturation of the eggs which always retain the same, polyploid number.

(2) Polyploidy has been induced in insects by experimental means. Species hybrids in moths, when backcrossed to one of the parent species, frequently produce triploid offspring. In the silkmoth, *Bombyx*, polyploid individuals have also been obtained by centrifuging the eggs at the beginning of development.

(3) In various species of animals, exceptional triploid individuals have been found. These originate from the union of a normal, haploid sex cell with an exceptional diploid cell that failed to reduce its chromosome number. Here belong the occasional triploid individuals of *Drosophila* which have played such an important role in genetics, particularly in the study of sex-determination. Here also belong the triploid amphibian embryos that have been recorded by several authors among preserved embryos of two species of frogs and two species of newts. With the exception of one parthenogenetic individual, all the triploids were found among supposedly normal, diploid embryos.

These observations indicate that, in amphibians, triploid embryos and larvae occur in nature. If it were possible to identify these exceptional individuals in life, we could then follow their development and study the effects of the abnormal chromosome condition.

Identification of Triploid Larvae in Triturus viridescens

Two years ago I began to investigate this possibility with larvae of the common newt, *Triturus viridescens*. Egg-laying was induced in the late fall by means of pituitary implants, and the eggs were allowed to develop to the time of hatching. How is it possible to determine the chromosome number in the cells of an organism without killing it? Plant geneticists have a very convenient method: young seedlings have a large number of small roots of which they can easily spare a few. These root tips are preserved, sectioned, and stained, and the chromosomes are counted in the dividing cells which are always present.

Young salamander larvae also possess a structure that can be removed without serious consequences: the posterior end of the tail. This tail tip can be fixed, stained, and mounted without sectioning. By the time it is ready for microscopical examination, the larva has begun to re-

generate a new one. In such tailtip preparations we find the darkly stained axis surrounded by a transparent fin that consists of two layers of epidermis and a little connective tissue in between. If we turn the oil immersion on a portion of the fin, we usually find cells in various stages of mitosis. In metaphase plates it is comparatively easy to count the number of chromosomes accurately.

In the early winter of 1937, tailtips of one hundred larvae were amputated, and the chromosome number determined in each. 96 were found to be diploid, with 22 chromosomes in all mitotic figures. The remaining four tailtips had 33 chromosomes in the clearest figures, and certainly more than 22 in all other metaphase plates. These tailtips therefore are triploid.

Since the size of a nucleus is roughly proportional to the number of chromosomes it contains, we can apply a secondary criterion to triploidy, namely, a general increase in the size of all nuclei. This is particularly well shown in epidermis nuclei, because they are flat disks. But the difference is also clearly visible in the nuclei of the rudiments of the lateral line organs that are spaced along the axis of the tail. At this stage of development, the first capillaries are growing out into the tailfin, and a few erythrocytes are occasionally caught in these at the time of amputation. The nuclei of the red blood cells are again larger in the triploid tailtips.

Effects of Polypleidy in Plants

In plants it is often possible to pick out polyploid individuals because of their external appearance. They are usually larger than diploid specimens. This gigantism is caused by the larger size of the individual cells. As a general rule, the size of a nucleus is directly proportional to the number of chromosomes it contains. Furthermore, there exists a definite ratio between the size of the nucleus and that of the cell as a whole, the well-known karyoplasmic ratio. The chromosome number is thus expressed in the size of the cells. The classical illustration is that given by Wettstein for a polyploid series of mosses. The moss plant is normally haploid—but diploid, triploid, and tetraploid plants may be produced by experimental means. The size of the leaf cells is roughly proportional to the number of chromosomes present.

The larger size of the cells automatically makes the polyploid plant a giant, if the total number of

cells in the plant remains about the same as in diploid plants. This is not always the case, particularly in the higher members of a polyploid series. It was recently shown by Greenleaf that tetraploid tobacco plants are larger than the diploid, while octoploid plants, with twice as many chromosomes, are smaller than the diploid, in spite of the fact that the size of their individual cells is increased in proportion to the chromosome number.

The effects of polyploidy mentioned so far are purely quantitative and probably all connected with the increase in the total mass of chromatin in each cell. In recent years, plant geneticists have called our attention to morphological changes that are qualitative: very often the shape of the leaves is different in polyploids, they are wider and thicker, or the general appearance of the plant is different, although it may be difficult to name the actual differences.

Finally, polyploid plants also show physiological changes, which have been little investigated so far. Triploid plants often grow more slowly than the diploid, triploid apples ripen more slowly and therefore keep better, they also contain more vitamin C. In polyploid mosses, the osmotic pressure of the cell sap decreases with an increase in chromosome number. Triploid aspen are more resistant to the attacks of a certain fungus.

General Effects of Triploidy on Salamanders

When we return now to our triploid salamanders, looking for striking effects caused by the addition of a third chromosome set, we will at first be greatly disappointed. The general course and the rate of development of the four triploid larvae of *Triturus* were entirely normal. One only of the four triploids was strikingly larger than the controls, from an early stage on. The remaining three triploid larvae were never significantly larger than the controls. They were preserved at the end of metamorphosis.

This absence of gigantism presents a most interesting problem. If all the cells are larger in the triploids, there must be fewer cells in the various organs to keep them within normal size limits. This is actually the case in all organs that have been studied so far, with the exception of the notochord.

Aside from the single exception of the notochord, all the available evidence demonstrates that a triploid salamander larva is capable of keeping the size of the organs and of the body as a whole within normal limits. The increase in size of the individual cells is compensated by a corresponding decrease in cell number. Apparently, fewer cell divisions take place than in normal diploid development. Why this happens, remains unknown: it seems to be an expression of the mar-

velous regulatory power of the living organism that manifests itself in many ways and always tends to return the organism to the normal condition, no matter what we do to it.

A similar regulatory mechanism seems to be operating in polyploid silkworms; they do not produce heavier silkthreads, as was originally expected, because they and their silk glands are of normal size, made up of larger but fewer cells.

Effects of Triploidy on Sex Chromosome Mechanism

In 1925 Muller proposed a hypothesis to explain the scarcity of polyploidy in animals. He pointed out that most animals have separate sexes which differ in their chromosomal make-up. While one sex has a pair of sex chromosomes, commonly known as X-chromosomes, the other sex has only one. The latter sex will produce two kinds of gametes in equal numbers, one with an X, the other without. It is the heterogametic sex, while the other sex is homogametic, all of its gametes are alike and carry an X-chromosome. Random fertilization will produce the two sexes in equal numbers. If more than two sets of chromosomes are present, this simple sex chromosome mechanism is interfered with, and normal bisexual reproduction becomes impossible.

The disturbance of the sex chromosome mechanism is most striking in triploid organisms. We know from the classical researches of Bridges on triploid *Drosophila*, that sex is not determined by the mere presence of one or two X-chromosomes. Rather it is the ratio of X-chromosomes to ordinary chromosomes or autosomes that matters. In *Drosophila*, the male is heterogametic. The ratio of X to autosomes is 1:2. In the female, it is 2:2 or 1:1. Triploid individuals may have 3, 2, or a single X-chromosome, in addition to 3 sets of autosomes. The first are normal females, since the ratio of X-chromosomes to autosomes is the same as in diploid females, 1:1. The individuals with one X, on the other hand, are "super-males", with an exaggerated male ratio of 1:3. They are typical males, but poorly viable and sterile. The individuals of the third class are neither male nor female, but combine characters of both sexes; they have a X/A ratio of 2:3 or 1:1.5 which is intermediate between the normal male and female ratios.

In the stick insect, *Carausius*, triploids have also been shown to be either normal females or intersexes. And the same applies to dioecious plants that possess a similar sex chromosome mechanism as *Drosophila*, e.g., the sorrel, *Rumex*, as has been shown by several Japanese investigators.

In moths, it is the female sex that is heterogametic. The male has 2 X-chromosomes. Con-

sequently, triploid individuals are either normal males or intersexes. Normal females are absent. In other words, triploidy always leaves the homogametic sex normal and changes the heterogametic sex to an intersexual condition.

Among the vertebrates, the mammals belong to the *Drosophila* type of sex determination, birds and reptiles to the moth type, while among the fishes both types are represented, sometimes in closely related forms. I have not mentioned so far the amphibians, because they are the only class of vertebrates for which no conclusive evidence is available regarding the sex chromosome mechanism. The sex chromosomes do not seem to be visibly differentiated from the autosomes, at least not in salamanders.

Breeding experiments with a few hermaphroditic frogs, by Crew and Witschi, afford evidence that the male frog is heterogametic. On the other hand, the results of experiments on sex reversal in male toads by Miss Ponse point in the opposite direction: the male toad seems to be homogametic.

In view of this uncertainty it becomes all the more important to obtain genetical evidence and to investigate the effects of triploidy on sex determination in the amphibia. We know that in other species of newts visible differentiation of the gonads into ovaries and testes takes place before metamorphosis. Since the four triploid *Triturus viridescens* were preserved during or after metamorphosis, the condition of their gonads may give us at least some preliminary information.

The normal process of sex differentiation in this species was studied in our laboratory by Mr. Fenninger. At the beginning of metamorphosis, at an age of about 16 weeks, ovaries and testes are clearly differentiated. The testis is a small compact structure, the germ cells are scattered throughout its cross section and have lightly stained and irregularly lobed nuclei. In the ovary we find in the center a small cavity. At the periphery there are nests of oogonia which have spherical nuclei of a very typical structure. There are also a few larger cells, young oocytes at the beginning of the growth period. Towards the end of metamorphosis, the testis still presents about the same appearance. The ovary has grown considerably, the oocytes in particular are much larger.

A glance at sections through the gonads of the four triploids showed that one possesses typical testes, the other three modified ovaries which are much less developed than in the controls. A small cavity is present, but there are few oogonia and no oocytes. The majority of the germ cells have the pale, very irregularly lobed nuclei that are

typical of the undifferentiated germ cells. The total number of germ cells in one triploid ovary was found to be only about one half of that present in the diploid control.

It is evident that triploidy does have an effect on sex differentiation. The ovaries alone seem to be affected, while the testes are normal. However, we cannot say at the present time whether these reduced ovaries represent an intersexual condition or merely a delay in the early development of the female gonads. Furthermore, we know only too well that, in amphibians, the development of the gonads may be affected by various factors outside the chromosomes.

We cannot hope to analyze this situation more completely unless we raise triploid salamanders to later stages where both ovaries and testes are more fully differentiated. Since it is rather difficult to raise common newts beyond metamorphosis, other species of salamanders, with a longer larval period, might furnish better material.

Polyploidy in Eurycea bislineata

For this reason I searched last winter for triploids among larvae of a lungless salamander, *Eurycea bislineata*. This so-called two-lined salamander grows to large size in the larval condition, and metamorphosis does not take place in nature until the third year. Fertile eggs were obtained by means of pituitary implants. Soon after the larvae hatched, they were isolated, and the chromosome number of each larva was determined in a tailtip preparation.

I could not find an account of the normal number of this species in the literature. Counts in the first two tailtips established it at 28. To my great surprise, the third tailtip to be examined already was triploid, with 42 chromosomes. This might have been mere luck—or an indication of a higher frequency of triploidy in this species. The latter seems to be the case, because, of 134 larvae examined so far, 13 were triploid—a frequency of almost 10%.

The triploids are of practically the same size as the controls. Again then, gigantism must be prevented by a reduction in the number of cells present in various organs.

Among the 134 larvae two tetraploid animals, with 56 chromosomes in the tailtip mitoses, were also present. These are the first cases of natural tetraploidy to be found in vertebrates. Recently, Kawamura discovered tetraploid and even hexaploid individuals among parthenogenetic tadpoles of a Japanese species of frog. They were not larger, but slightly smaller than triploid and diploid animals.

One of the two tetraploid larvae could not be induced to feed after it had exhausted its yolk supply. The other tetraploid fed well but reacted more slowly than triploid and diploid animals. It lived for about 7 months when it had to be fixed because of severe edema of the body cavity that had developed only recently. Do these troubles indicate that, with the tetraploid condition, we have come close to the limit of viability, perhaps because of the larger size of the individual cells?

Indeed, since the tetraploids are not larger than normal, we may expect that all organs are made up of half the number of cells with twice the normal volume. This is probably the case, as I have found in a rapid examination of the sections through the younger larva. Such a condition may have harmful consequences, for the following reasons: in general, the larger cell size would tend to interfere with the rapid exchange of substances between center and surface of individual cells. The reduction in the number of red blood cells may have serious effects. Furthermore, if the brain and spinal cord have only half the normal number of ganglion cells, this may well affect to some extent the functioning of the central nervous system. Or, to mention a final point: if the retina of the eye contains half the normal number of visual cells, the visual acuity of the tetraploid animals must be reduced. In any case, the further investigation of the morphological and physiological effects of polyploidy should produce interesting results.

Experimental Induction of Triploidy in Triturus viridescens

For such an investigation, we need a large amount of material. The natural frequency of triploidy has not yet been determined accurately. It seems to vary between different species: perhaps it is as high as 10% in *Eurycea*, but less than 1% in *Triturus*. It would be very convenient if we were able to increase this frequency by experimental means. In plants, polyploidy may be induced not only by treatment with colchicine, but in several other ways, e.g., short exposure to low or high temperatures.

Several years ago a French embryologist, Rostand, claimed that exposure of frog's eggs to temperatures close to freezing produced a considerable number of diploid, unreduced eggs, perhaps through inhibition of the second maturation division which takes place after laying. If Rostand's observation is correct, such a treatment, when ap-

plied to fertilized eggs, should produce triploid embryos in greater number.

Following this suggestion, Mr. Griffiths last winter tested the influence of low temperature on eggs of *Triturus viridescens*. Freshly deposited, fertilized eggs were placed in a refrigerator the temperature of which varied between .5 and 3° above freezing. After 16 to 26 hours, they were removed and allowed to develop at room temperature. The rate of mortality was much higher than in the controls, but 35 larvae hatched and could be subjected to the tailtip test. The results went far beyond our fondest hopes: only one of the 35 larvae was diploid, 24 were triploid, and 10 haploid. The 117 control larvae were all diploid.

The majority of triploid larvae from these experiments developed normally to metamorphosis. Eight of the ten haploid larvae died during the fourth week, only one lived for over three months. This agrees with what we have learned from other haploid amphibian larvae that were produced by different methods: their viability is much reduced.

In closing, I wish to raise another question: does polyploidy occur in higher vertebrates, in birds and mammals? There is no obvious reason why it should not—we even have some cytological evidence that diploid sperms are produced occasionally in mammals which, on fertilization, would make a normal egg triploid. Unfortunately, the higher vertebrates are difficult material for any chromosome problem, since the cells are small, and the chromosomes are many. To make matters worse, there is no larval stage with an easily removable tailtip. Under such circumstances it may take a long while before this question can be answered.

In the meantime it will be more profitable to stay with the amphibians and to follow up the various problems which have merely been touched on so far: the natural frequency of triploidy in different species of amphibians; the actual origin of the polyploid larvae in nature; the mechanism of induction of triploidy and haploidy by cold treatment; the morphological and physiological effects of polyploidy; the relation of cell size and cell number in the growth of various organs; the effects of polyploidy on sex.

Finally, there is the whole field of experimental amphibian embryology, where the availability of triploid and tetraploid material may have interesting applications.

(This article is based upon a lecture entitled "Polyploidy in Amphibia," given at the Marine Biological Laboratory on July 7.)

EFFECTS OF TEMPERATURE ON STARCH AND FAT IN CHILOMONAS

DR. JAY A. SMITH

The Johns Hopkins University

Chilomonas paramecium is a biflagellate, about 30 μ long, that contains about 20 starch particles and about 15 fat globules.

The results of experiments dealing with the effects of temperature on the frequency of division were published in this journal (vol. 13, no. 2, p. 35). In general, they confirm those of many investigators working with various organisms, namely, that in viable temperatures, an increase in the temperature causes an increase in the frequency of division. During the past winter, a study of the starch and fat in *Chilomonas* was made in the hope that something regarding the control of the frequency of division might be discovered. The results are interesting, though they deal with gross phenomena and do not delve into the details of the metabolism of the organisms.

In the course of these experiments, a temperature gradient varying from 9°C. to 39°C. was maintained constant to $\pm 0.25^\circ\text{C}$. in a large constant temperature bath. The chilomonads were grown in a sterile solution containing sodium acetate, calcium chloride, magnesium chloride, ammonium chloride, ammonium sulphate, and potassium acid phosphate at a hydrogen ion concentration of pH 6.8. The volume of starch and fat was measured as follows: several chilomonads were drawn into a capillary tube, ejected on a slide, and treated, first with Lugol's solution, which stained the starch blue, then with a saturated alcoholic solution of Sudan III, which stained the fat orange. Five such organisms taken at random were examined with a microscope equipped with an ocular micrometer, and the size of each starch particle and each fat globule determined and recorded. The mean size and the mean volume of the starch and fat particles in the individuals were calculated, and then the mean volume for the five chilomonads.

Three temperature ranges were distinguished: viable temperatures, lethal low temperatures, and lethal high temperatures.

The results of experiments on chilomonads grown in viable temperatures (temperatures in which the chilomonads will live indefinitely), in these experiments from 13.5°C. to 30°C., follow. The volume of starch remains constant, but the volume of fat is smaller at the higher temperatures. This means that, although the organisms are dividing faster at higher than at lower temperatures, the starch content remains the same. Why the starch content remains the same while the fat content decreases with a rise in temperature is uncertain, but the results of experiments

with lethal low temperatures indicate that this result is correct.

Look at the problem from another angle. The volume of starch and fat per chilomonad is known for viable temperatures. From the study of the frequency of division, the number of chilomonads that would be produced in a given time—for instance, 24 hours—is known. Now, if the volume of starch and the volume of fat is multiplied by the number of organisms expected in 24 hours, an estimation of the volume of starch and fat that would be produced in this 24 hour period can be obtained. This calculation shows that as the temperature rises, the production of starch and fat increases, reaching a maximum at the temperature of maximum reproduction, namely, 30°C. Above this temperature, accurate measurements are impossible due to the fact that some organisms are dividing while others are dying.

From these facts, one might conclude that, within the viable temperature range, the starch-fat production is the factor that controls the frequency of division, or that the production of starch-fat and the division proceed at such independent rates that, by chance, the former remains constant.

The second temperature range is lethal low temperatures. At 9.5°C., the chilomonads do not divide, even though left for a week or longer, but they will survive and remain quite viable for periods of four weeks or longer. At this temperature, the starch volume decreases rapidly to about one third its normal volume, while the fat increases about eight times its normal volume. Apparently there has been little or no synthesis of starch during periods as long as four weeks at 9.5°C., and the only change evident, at least with the method used, is a transformation of starch into fat.

Now regarding the third temperature range, lethal high temperatures:

Above 30°C., the chilomonads eventually die, and death is accompanied by a decrease in the frequency of division and by an increase in the volume of starch and fat per organism.

At 32.5°C., the starch-fat remains at a volume characteristic of chilomonads living in viable temperatures until about 60 hours. Then there is an increase in the volume of both which continues until the chilomonads gradually die off at about 110 hours. The chilomonads divide only four times during this 110 hour period, whereas they divide twelve times during an equal period at 30°C., where maximum reproduction occurs.

Similarly at 35°C. there is an increase in the volume of starch and fat, this time beginning when the chilomonads are transferred to this temperature and continuing until the organisms die at about the end of about 86 hours. At this time, the starch is about five times and the fat about twenty five times that found at viable temperatures. There is no division at all. Thus there has been a greater increase in starch-fat, but the chilomonads did not live as long as they did at 32.5°C.

At another temperature, 36.5°C., a similar effect is noted. There is an increase in the starch and fat that begins when the chilomonads are transferred to this temperature and continues until the organisms die, this time after only 26 hours. The chilomonads live for a shorter period of time than at either of the lower lethal high temperatures, and the increase in starch-fat is less but is nevertheless present.

At a still higher temperature, 39°C., the chilomonads die even sooner, this time in 10 hours, and the starch and fat do not change at all during this brief time.

Lethal high temperatures, then, cause three gross changes: first, and most obvious, death; second, a decrease in the frequency of division; and third, an accumulation of starch and fat. It seems that death of the organism and the decrease in the frequency of division might be related, but they are not related to the accumulation of starch and fat except that synthesis of starch and fat

probably continues at a rate little changed from that at viable temperatures, and the decreased frequency of division results in an accumulation of starch and fat in the individuals.

To sum up, starch and fat in *Chilomonas*, which are vitally essential substances, change greatly in quantity with changes in environment, notably temperature. In viable temperatures, the volume of starch in the individual chilomonads remains constant, while the volume of fat decreases somewhat as the temperature rises. This suggests that within the viable temperature range, synthesis of starch and fat is the factor that controls the frequency of division. At lethal low temperatures, there is no synthesis, and the only change evident is a transformation of starch into fat, indicated by a decrease in the volume of starch simultaneous with an increase in fat. At lethal high temperatures, death is accompanied by a decrease in the frequency of division and an accumulation of both starch and fat; synthesis continues and these substances accumulate in the non-dividing organisms. This action is quite opposed to that occurring at viable temperatures where the volume of starch and fat remains practically constant; therefore the postulation that synthesis of starch and fat controls the frequency of division becomes cumbersome except within the viable temperature range.

(This article is based on a seminar report entitled, "Some Effects of Temperature on the Starch and Fat in *Chilomonas paramecium*," presented at the Marine Biological Laboratory on July 5.)

RESPIRATION IN CHILOMONAS PARAMECIUM

DR. JOHN HUTCHENS

The Johns Hopkins University

Chilomonas paramecium is a colorless, unicellular, biflagellated organism remarkable because of its ability to grow and divide in very simple media. It is ca. 30 μ long and 15 μ wide and contains many starch particles and fat droplets. Pringsheim (1921)¹ reported that *Chilomonas* will grow in a solution containing only glycine, CH_3COONa , K_2HPO_4 , and MgSO_4 . Mast and Pace (1933)² verified Pringsheim's observations and found in addition that *Chilomonas* will grow in still simpler solutions. They found that *Chilomonas* grows as well in darkness as in light, that it can obtain nitrogen from amino acids, urea, or ammonium compounds but not from nitrites, ni-

trates or from the air, that it can obtain carbon from glycine, glucose, urea, acetates, formates, or from carbon dioxide, but not from carbonates. It appears that *Chilomonas* needs only nitrogen, carbon, oxygen, hydrogen, magnesium, potassium, sulfur, and phosphorous. If any other elements are necessary, extremely minute quantities suffice.

The source of the energy necessary for the syntheses performed by *Chilomonas* under the unusual conditions described is of prime interest. Naturally one looks first to the oxidations performed by the organism. Mast, Pace, and Mast (1936)³ studied the respiration of chilomonads grown in a variety of culture media and reported that in a medium containing CH_3COONa , NH_4Cl , K_2HPO_4 , and MgSO_4 the average rate of

¹Pringsheim, E. G., (1921), *Zur Physiologie der Saprophytischen Flagellaten.*, Beitr. z. allg. Bot., Bd. 2, S. 88-137.

²Mast, S. O., and D. M. Pace, (1933), Synthesis from inorganic compounds of starch, fats, proteins, and protoplasm by the colorless animal, *Chilomonas paramecium*, *Protoplasma*, Bd. 2, S. 326-359.

³Mast, S. O., D. M. Pace, and L. R. Mast, (1936), The effect of sulfur on the rate of respiration and on the respiratory quotient in *Chilomonas paramecium*, *Jour. Cell. and Comp. Physiol.*, V. 8, pp. 125-139.

oxygen consumption is $0.17 \text{ mm}^3/\text{hr.}/10,000$ chilomonads, this rate decreasing rapidly if the acetate is omitted. They also reported an average respiratory quotient of 0.31 for chilomonads grown in a variety of media, suggesting that this low respiratory quotient indicated fixation of CO_2 by the chilomonads even in media containing an adequate carbon source. Since the respiratory quotient, the ratio of the number of mols of CO_2 produced by a cell to the number of mols of O_2 consumed, is unity if carbohydrates are oxidized, ca. 0.8 if proteins are oxidized, and ca. 0.7 if fats are oxidized, a respiratory quotient of 0.3 would indicate that some substance other than carbohydrate, fat, or protein was being oxidized, or that some of the CO_2 produced during oxidation of these substances was being used by the cell. Mast and Pace chose this latter alternative.

Primarily because of the low respiratory quotient claimed for *Chilomonas*, but also because of the apparent absence from the media used for culturing it of such elements as Cu and Fe ordinarily considered necessary for formation of the respiratory enzymes found in most cells, and because it seemed desirable to attempt to correlate the rate of consumption of oxygen by the chilomonads with their physiological condition, a comprehensive study of the respiration of this organism was undertaken. The portion of this work reported here concerns two points: the correlation of the rate of oxygen consumption by the chilomonads with the age of the culture from which they are taken, and the value of the respiratory quotient under various conditions.

The chilomonads used were grown in sterile, pure, mass cultures at 25°C . in a medium containing CH_3COONa , NH_4Cl , $(\text{NH}_4)_2\text{SO}_4$, K_2HPO_4 , CaCl_2 , and MgCl_2 . The solution was well buffered by the acetate and phosphate, and the Hc was maintained at pH 6.8. In such cultures inoculated with ca. 400 organisms/cc. growth is rapid during the first 48 hours; from 48-72 hours the cultures have their maximum population of 5000-7000 chilomonads/cc.; on the fourth day the organisms begin to aggregate in small groups; and by the fifth day they have stuck together in small clumps which sink to the bottom of the culture flask. At this time all of the chilomonads are dead.

The rate of oxygen consumption and the respiratory quotient of chilomonads taken from cultures at various times following inoculation were measured at 25°C . using simple Warburg respirometers. The rate of oxygen consumption was measured by the direct method, and the respiratory quotient either by the so-called plus and minus alkali method or by the first method of

Dickens and Simer. All of these methods are described by Dixon (1934)⁴.

Dealing first with the rate of oxygen consumption by chilomonads taken from cultures at various times following inoculation we find that the rate varies inversely with the age of the culture, being for strain $\times 2$ $0.40 \text{ mm}^3/\text{hr.}/10,000$ chilomonads at 24 hours following inoculation of the culture, $0.23 \text{ mm}^3/\text{hr.}/10,000$ at 48 hours, and $0.17 \text{ mm}^3/\text{hr.}/10,000$ at 72 hours, and for strain $\times 1$ 0.35 mm^3 , 0.17 mm^3 , and 0.12 mm^3 respectively at corresponding times following inoculation of the cultures. It is obvious from these results that the rate of oxygen consumption by the chilomonads varies inversely with the age of the culture, and that the rate also varies with the strain of chilomonads used.

Concerning the respiratory quotient of *Chilomonas* we see that it varies inversely with the age of the culture from which the organisms are taken, i.e., directly with the rate of oxygen consumption. When the rate of oxygen consumption is $0.40 \text{ mm}^3/\text{hr.}/10,000$ chilomonads the respiratory quotient is 0.93, and when the rate of oxygen consumption is $0.12 \text{ mm}^3/\text{hr.}/10,000$ chilomonads the respiratory quotient is 0.74. The intermediate values between these two extremes are consistent with this tendency. This means that in young cultures which are growing rapidly and in which the organisms are consuming much oxygen the respiratory quotient is high, and as the cultures grow older and the organisms cease to grow and divide the rate of oxygen consumption and the respiratory quotient both decrease, but in no case was a value of the respiratory quotient lower than 0.7 recorded. There seems, then, no need to postulate fixation of CO_2 by *Chilomonas* in the solution described above.

Just what the changing values of the respiratory quotient mean is hard to say, and until the products of the oxidations are known one cannot say with certainty what they do mean. Obviously when the respiratory quotient is high, proportionally more carbohydrate and/or acetate is being oxidized. Whether the decreased values signify oxidation of a higher proportion of fat or the oxidation of some ammonia which would, of course, yield no CO_2 it is impossible to say. I have adopted as a working hypothesis the idea that in young cultures in which growth is rapid and much energy is needed more acetate is oxidized and that the proportional amount of this substance oxidized falls off in the older cultures.

(This article is based upon a seminar report given at the Marine Biological Laboratory on July 5.)

⁴Dixon, M., (1934), *Manometric Methods*, 122 pp., Cambridge.

EMBRYOLOGY CLASS NOTES

"And by their color shall ye know them" is only too true of the embryology class, their faculty, and friends who demonstrated that they can play as hard as they can work by going on an all-day picnic last Saturday. Although the sun was invisible through the fog, the damaging rays came through and did their insidious work. The high light of a day of ball-playing, swimming, burrowing in the fine sand, hiking through woods barefoot, and lazy lolling in the sun on the fine beach at Tarpaulin Cove was the dinner which included clams, lobster, and watermelon cleverly cut by Dr. Goodrich. The exponents of various schools of thought on the proper way to get at the lobster meat demonstrated their methods for the benefit of the novices. In the end the advocates of the hammer seemed to have a lead on those who slammed the tough carapace against trees. Only one seemed dexterous enough to draw the tender morsels from their shells by the aid of improvised chopsticks. The *Nercis* and the *Winifred* carried a completely happy, sand-covered crowd toward Woods Hole late in the afternoon. After supper, however, it began to be another tale as part of the class gathered in the court of the lab to discuss for an hour one topic of conversation, sunburn.

Earlier in the week, the class had been working long hours doing the experiments outlined by Dr. Schotté in the work on echinoderms. Many were the sea urchins thwarted by use of lithium, hypertonic sea water, and acid. The experiments on parthenogenesis aroused the greatest interest, and the loudest shouts of glee when the investigators discovered that they had actually raised fatherless sea urchins to the pluteus stage. As introduction to one of the best lectures of the series, Dr. Schotté confessed that he had left his notes in Amherst and that one of his colleagues at the breakfast table had suggested that he just let Providence put the words in his mouth. Dr. Schotté said, "I've always been interested to know how Providence feels about parthenogenesis!"

One of the high lights of the days that were spent on experimental work was the seminar held late Friday during which several of the students reported on the work they had done. Lively discussion followed some of the reports of experiments that had been made by most of the class. At the close it was rewarding to hear Dr. Schotté say that he had never had a class here that was as studious and interested as ours!

A somewhat different angle of embryology was presented by Dr. Frank Lillie in his lecture on "The Feather as a Developmental System." His explanation of experimental work carried on in his own laboratory was supplemented by his slides showing the growth of feathers. This was espe-

cially interesting since the feather is little known as a subject for experimentation.

Polar bodies, cleavages, and vitelline membranes are once again under the microscopes as the class tackles specifically the problem of fertilization under the guidance of Dr. Costello.

During the work of the first morning, Monday, the class departed en masse to the railroad station to bid farewell to Dr. Goodrich as he left for a few weeks of studying the tropical fish in Bermuda. His interest in the students, his good fellowship, and his capable organization of the course have meant so much to the budding embryologists that everyone was sincerely sorry to see him leave, and meant it when singing, "For he's a jolly good fellow - - -."

—Frances Pauls.

PROTOZOOLOGY CLASS NOTES

Last week proved to be a busy one for the Protos. Dr. Calkins concluded his introductory series of lectures on a general survey of the Protozoa and their morphology and has begun his lectures on vitality for which he is justly famed. His work and its philosophical implications are being incorporated into the biological background of the embryonic Protos with much interest. Especially interesting also was Dr. Kidder's lecture on chromosomes and chromosomal activity of the Protozoa. We are being exposed to many new ideas on the cytology and physiology of the wee beasties.

The Protos have joined the collectors of rarities in attempting to get their drawing plates returned with Dr. Kidder's stamp of approval. The visual imagination of some students has resulted in drawings of seemingly theoretical organisms while other students should be momentarily worried as to the severity of penalties for the infringement of the copyright laws. Protoman Vince Groupé wonders if Dr. Kidder would approve of an unsigned drawing by Dr. Kidder. In addition to drawing, the Protos are spending a good deal of time making stained preparations. An unconfirmed rumor has it that some student found a Protozoan on a finished slide.

Hopes for a safe and sane Fourth were shattered when the class went down to the beach and blew up their savings in the form of 2-inchers and skyrockets; also blown was Brown's researchman Ormsby who lost several square inches of sunburn and epidermis fleeing from wildly thrown fireworks. The Protos' intentions were better than their aim. High spot in humor for the week occurred when a ciliate bit off more than it could chew under a 'scope; gurgled Wheaton's giggling Jeanne, "Look, it's *regurgarating!*" Also heard, "I'm not smoking, Miss Dewey, it's just the fog I'm in."

Several of the group went to Nantucket on Sunday. Those who cycled for 23 miles while there have shown an indisposition to remain seated for any length of time since then. Plans are being made to hold a picnic next Saturday. This will be the first picnic Protozoology has ever held here. The enthusiastic Protos plan merriment and good food. If the scales continue to read higher each time we weigh, after all, there is girth control.
—Cecil Reid Reinstein

BOTANY CLASS NOTES

As usual, the field trips are a high point in the activities of the botany class. It rained cats and dogs the day of the first fresh-water expedition, but nobody minded, because we were all up to our necks in Cedar Swamp anyway. A fallen log resulted in the rather complete inundation of one of the *botanistes*. Examination of the material on our return showed a goodly collection of genera despite the ravages of the hurricane and the relatively small size of the class this year.

The next week, the class migrated to Cuttyhunk where the local inhabitants were amazed at Dr. Taylor's Mexican sombrero with its two-foot turkey feather. A fine mess of *Chara*, a snapping turtle, and some excellent *Euglena sanguinia* were brought home. That evening some fifty genera were identified.

Pasque and Nashawena were visited on the next trip. While the botanists were walking and wading across Pasque giving the ticks a thrill, the crew on the *Nereis* had a merry time chasing a flock of young geese. They only got the bird for their trouble. Besides a decoy, a float from a fisherman's net, and some miscellaneous souvenirs, a fine crop of Desmids was collected.

The last field trip was a dredging voyage. We made hauls off Nobska and Vineyard Haven. At the latter place, there was some excellent *Agardiella*, a bright red cladified form.

Provided with five pounds of hamburger and a case of beer, the class took an unofficial field trip to Sippiwisset Beach on July Fourth. What with song singing and whatnot, an excellent time was had by all. Other social activities include a revival of the ten o'clock tea. It was found that tea balls were unnecessary because the rust in the bottom of the teakettle provided ample flavor for the beverage. An unhopd for economy was thus realized.

Two of the regular Thursday evening seminars have been held so far. At the first, Vivian Trombetta reported on her research on the correlation between nuclear volume and cell size. Jim Merry summarized the work that has been done on growing plant embryos on culture media. Lois Lillick reported on the phytoplankton of the Gulf of Maine and Mr. Rakestraw of the Oceano-

graphic Institute discussed the nitrogen cycle with relation to the phytoplankton at the second meeting.

Other highlights of the season so far include such pleasantries as sunburn, and Dr. Runk's trousers hanging out the window. An intensive search revealed that what was at first believed to be a putrifying embryologist was a dead crab under one of the lab tables. So far the summer has proved profitable and enjoyable for all, and the prospects for the future are likewise.

—Robert Page

PHYSIOLOGY CLASS NOTES

The Retreat from Tarpaulin Cove

At 9:00 in the morning of what promised earlier to be a fine day, the physiologists up-anchored and awayed on the spirited (in deference to Captain Smith) *Winifred*.

With sails taut and a belching exhaust (the wind was in the wrong direction for some of us) our transportation gastropoded lethargically down the Sound to a point 3 or 4 miles below the Cove. Here, six dinghied to the shore and proceeded to walk back. In all fairness to himself and to others, California's Bell should take up some other—any other—activity than piloting a dinghy. His course resembled a rat maze as he unravelled his meager store of nautical acumen. Some time later the *Winifred* sidled up to the glistening Cove sands and unlimited quantities of good things were taken ashore. Swimming and baseball temporarily drove food from our thoughts. The Wherry Racketeers had the game well under control throughout (just ignore statements to the contrary) in spite of vigorous efforts by the Fisher Untouchables. Early, dissatisfaction was evidenced with the umpiring and for the remainder of the game rules were shelved. This, and this only, prevented the Untouchable defeat from being overwhelming. Those folk may be good at marbles but they cannot play baseball.

Food—that word which conjures up extravaganzas of gastronomical delight. The pen is inadequate. Nearly everyone went back for more and some more than once and all returned "with bases loaded." After most of us had attained a certain degree of satisfaction, the master-of-ceremonies, Brother Wherry, took charge and he more or less managed to divert our minds to things cultural. Expensive and appropriate gifts, accompanied by literary gems, were presented to our mentors, and the program concluded with an amusing and well-executed frog tale by Dr. Packard.

While this merriment was on, ominous-looking clouds were gathering unnoticed in the northwest, to be followed shortly by vivid lightning and much

(Continued on page 42)

The Collecting Net

A weekly publication devoted to the scientific work at marine biological laboratories.

Edited by Ware Cattell with the assistance of Boris I. Gorokhoff and Mona Garman.

Entered as second-class matter, July 11, 1935, at the U. S. Post Office at Woods Hole, Massachusetts, under the Act of March 3, 1879, and re-entered, July 23, 1938.

Introducing

DR. PER OLOF THERMAN, Assistant in Physiology at the Physiological Institute at the University of Helsingfors; Rockefeller Fellow at Harvard University.

Dr. Therman received his degree of doctor of medicine at the University of Helsingfors, Finland, in 1938, and has spent most of his time since in the United States. A native of southern Finland, he carried out research on the neurophysiology of the retina under Dr. Granit in preparation for his doctor's degree.

After working during the summer of 1938 in the Physiological Institute of the University of Helsingfors, he arrived in the United States in September of that year in order to conduct research as a Rockefeller Foundation Fellow at Harvard University. He studied brain-waves under Dr. Hallowell Davis, and worked on micro-electrode technique with ganglia under Dr. Alexander Forbes.

In April of this year, Dr. Therman attended the meeting of the American Physiological Society in Toronto, Ontario; on the trip he travelled to various universities and medical centers, visiting such places as Chicago, Rochester, Minn., St. Louis, Baltimore and Philadelphia.

He is continuing work this summer at Woods Hole upon the retina, using as material the eye of the squid, which has the receptors and the ganglion cells separate and thus makes certain types of neuro-physiological investigation possible.

At the end of this summer he plans to return to Harvard for two months to complete his research there. In November he will go to the Rockefeller Institute in New York to study electro-physiological technique under Dr. Gasser. Early in December he will leave for Finland, where he will resume his position in the Physiological Institute at the University of Helsingfors. During his trip to America, Dr. Therman has been accompanied by his wife, Dolly; a daughter, Christina, was born to them on this side of the ocean.

AN ANNEX TO HARVARD HOUSE IN CUBA

DR. THOMAS BARBOUR

Director of the Museum of Comparative Zoology, Harvard University

For some time past it has occasionally been impossible to accommodate investigators from other universities at the Biological Laboratory of the Atkins Institution, Soledad, Cienfuegos, Cuba. This has caused much regret but such occurrences were due to the fact that the laboratory was filled by students and officers of Harvard University, hence it was impossible always to provide for other scientists to make use of the facilities offered by the Harvard Botanical Garden, the Harvard House Laboratory and the easily reached adjacent sea coast and mountains.

This situation is now entirely changed. A new building has been erected with comfortable sleeping accommodations for sixteen persons so that there should be no question, whatever, of overcrowding. This building, erected on the top of the hill, above Harvard House, is easily accessible from the laboratory and dining room there and it is so situated as to get the full benefit of the breeze which blows down from the Trinidad Mountains at night. This new dormitory is called Casa Catalina.

Harvard University, therefore, now will welcome inquiries concerning the facilities which are offered at the Cuban Station. Board and lodging are provided at \$2.50 a day and inquiries concerning the Station may be addressed to Thomas Barbour, Custodian, Museum of Comparative Zoology, Cambridge, Massachusetts.

CURRENTS IN THE HOLE

At the following hours (Daylight Saving Time) the current in the Hole turns to run from Buzzards Bay to Vineyard Sound:

Date	A. M.	P. M.
July 15	3:28	3:36
July 16	4:20	4:31
July 17	5:07	5:19
July 18	5:58	6:11
July 19	6:46	7:03
July 20	7:32	7:56
July 21	8:25	8:57

In each case the current changes approximately six hours later and runs from the Sound to the Bay.

ITEMS OF INTEREST

DR. AND MRS. CHARLES PACKARD will be at home to members of the laboratory Sunday afternoon, July 16, from 4:30 to 6 o'clock and on the two remaining Sundays of the month.

DR. ROBERTS RUGII, who has been instructor in zoology at Hunter College, has been appointed associate professor of biology in Washington Square College of New York University to succeed Professor A. F. Huettner.

DR. TRACY M. SONNEBORN of the Johns Hopkins University has been appointed associate professor of zoology at Indiana University.

DR. RUSTUM MALUF, who has been a fellow in physiology at Yale University, has been appointed Johnston scholar in zoology at Johns Hopkins University.

DR. JOHN O. HUTCHENS has been awarded a National Research Council Fellowship in Biology to conduct research in the Carlsberg Laboratory in Copenhagen with Dr. Heinz Holter on carbon and nitrogen metabolism.

MR. PAUL CALABRISI has been appointed instructor in anatomy at George Washington University. He had been a fellow in anatomy at that institution.

DR. THOMAS H. LANGLOIS, Director of the Franz Theodore Stone Laboratory of the Ohio State University was elected President of the American Fisheries Society at its recent annual meeting in San Francisco.

MR. WILLIAM M. ROGOFF, who took the embryology course at the Marine Biological Laboratory last summer, has been awarded a University scholarship at Yale University.

DR. FREDERICK P. GAY, professor of bacteriology at the College of Physicians and Surgeons in Columbia University, died yesterday. Dr. Gay would have been 65 years old on July 22.

DR. RUTH B. HOWLAND, associate professor of biology at Washington Square College in New York University, has been on leave of absence since February 1938 and will return in September of this year. She has been working at the Osborn Laboratory at Yale University, and is now spending the summer at the Bermuda Biological Station.

DR. W. E. MARTIN, assistant professor of zoology at DePauw University, has taken the place of Dr. W. F. Hahnert as instructor in the invertebrate zoology course at the Marine Biological Laboratory. Dr. Hahnert is teaching this summer at the F. T. Stone Biological Laboratory in Put-in-Bay, Ohio.

DR. SELMAN A. WAKSMAN, professor of microbiology at Rutgers College, is returning to the New Jersey State Agricultural Station tomorrow to continue his research there. Mrs. Waksman and their son Byron, who is taking the protozoology course, will remain in Woods Hole until the beginning of August.

DR. H. HERBERT JOHNSON, associate professor of biology at the College of the City of New York, has been on leave of absence since February 1 and is devoting a year to the completion of his text book on vertebrate embryology. Dr. Johnson has worked at the Marine Biological Laboratory.

DR. AND MRS. FRANZ WEIDENREICH are visiting Woods Hole for a few days. They will leave at the beginning of next week for California but will return to Woods Hole in the middle of August to work in the library. Dr. Weidenreich is a distinguished anthropologist from Peking Union Medical College.

PROF. HORACE W. STUNKARD, professor of biology at the University College of New York University, is on sabbatical leave and is spending the summer in Hamburg, Germany, with his family. He is conducting research at the Institute for Ship and Tropical Diseases and is expecting to return to this country on September first.

Several members of the Woods Hole Oceanographic Institution will participate in the Third International Congress on Microbiology which convenes in New York City from September 2 to 9 under the presidency of Dr. T. M. Rivers of the Rockefeller Institute. Dr. S. A. Waksman, who is a member of the executive committee, will present a paper on the classification of Actinomycetes. Dr. C. ZoBell, Dr. C. E. Renn and Dr. B. Lloyd will give papers before the Congress on various phases of marine bacteriology.

ADDITIONAL INVESTIGATORS

- Bilka, P. J. asst. biol. Trinity (Conn.). OM 28.
 Crawford, J. D. Milton Academy (Milton, Mass.). Br 309.
 Crowell, Villa B. Miami. OM 25. D 207.
 Foster, R. W. Milton Academy (Milton, Mass.). Br 309.
 Fowler, Coleen asst. prof. zool. Hopkins. Br 217c.
 Furth, Olga B. res. asst. path. Cornell Med. Br 335. A 108-109.
 Gaines, Elizabeth res. asst. biol. Amherst. Br 313.
 Hendee, Esther C. asst. prof. biol. Russell Sage (Troy, N. Y.). Bot 1. K 2.
 Hunninen, A. V. prof. biol. Oklahoma City. Br 115.
 Love, Genevieve indep. invest. Brookville, Pa. OM 45.
 Pyke, D. A. Cambridge (England). Rock 6.
 Ramsdell, Pauline A. Swarthmore. OM 29. W B.
 Rous, P. mem. Rock. Inst. Med. Res. Br 208.
 Walker, P. A. instr. emb. Connecticut State. Br 340.
 Wilhelmi, R. teaching fel. New York. Br 232.

ITEMS OF INTEREST

DR. R. P. BIGELOW, emeritus professor of zoology and parasitology of the Massachusetts Institute of Technology, has recently revised the book entitled "A Short History of Science" by the late W. J. Sedgwick, who was an incorporator and for many years a trustee of the Marine Biological Laboratory. Dr. Bigelow is at his home with his family on Gardiner Road.

DR. AND MRS. EDWIN G. CONKLIN celebrated their golden wedding anniversary at Princeton on June 13. Friends and relatives joined in the observance with gifts and congratulations.

MR. HAROLD KENNETH FINK, who was at the Marine Biological Laboratory in 1937 and 1938, and is now at the California Institute of Technology, is touring the country with his two-months' bride, Elizabeth Jane Taylor Fink.

MISS MARGERY FULLER MITCHELL, daughter of Dr. Philip H. Mitchell, professor of biology at Brown University, and Mrs. Mitchell, was married at Providence on June 30 to Mr. Robert E. Tonks of Poughkeepsie, N. Y. Mr. Tonks is on the teaching staff of Suffield Academy (Connecticut), and his father is professor of art at Vassar College. The couple have gone on a wedding trip to Nova Scotia and will spend the month of August at Woods Hole.

An honorary degree of Doctor of Sciences was awarded to Dr. Thurlow Christian Nelson, Chairman of the Department of Zoology at Rutgers University, at the Commencement exercises at Rutgers on June 11. The following citation was read by Dr. Robert C. Clothier, President of the university:

Thurlow Christian Nelson, Chairman of the Department of Zoology: It is hard to address, with formality appropriate to such an occasion as this, a man who holds in the life of the university and the admiration of his fellows the place which you hold. Custom would decree my addressing you as distinguished scientist, son of a distinguished scientist; as gifted teacher; as creative scholar whose researches, especially in the field of oyster culture and parasitology, have yielded rich returns to the people of our state and nation. All these things are true, and we honor you for them. But we honor you no less for your integrity of character and workmanship, for your kindness, for your gift of friendliness, for the affection and admiration with which your associates and students hold you. It is twenty-six years since you received your last Rutgers diploma. It is time you received another. Here in the presence of your friends, I confer upon you, honoris causa, the degree of Doctor of Sciences.

PHYSIOLOGY CLASS NOTES

(Continued from page 39)

thunder. With the latter, Captain Davenport sought refuge in a nearby barn. Another hour or so of sunning, yarning, and duck-on-the-rocking and the Winifred got started for her home berth. A goodly number of the probably-wiser returned on her and about twenty remained to hike.

"Then the rains came." Not a dinky, little Scotch mist but in ton-lots and accompanied by hail the size of nuggets. In no time at all we were soaked to the epidermis, in spite of the fact that we had gathered beneath a hopelessly inadequate tree and rendered feelingly "It Ain't Going to Rain No More," and some may have regretted their decision to walk as no let-up occurred and the *Winifred* became more and more ghostlike in the distance.

Shortly after 5:00 the trek began. The first 200 yards were fine, our spirits rising as the heavens brightened. All hope was abandoned, however, when the rain began again and we trudged on. Then we realized how Napoleon must have felt after Moscow and our sympathies were with him. Mile after mile, up hill and down. Slosh! Slosh! Slosh! Some sang and others talked to keep up a moist morale. Amherst's

Plimpton, in the capacity of Silver, with Larry Irving up, told hair-raising tales of his near-experiences with the Aztecs. Evidently he succeeded in keeping Larry's thoughts on other subjects than rain and cold as the last 30 yards were covered at a "dead" trot accompanied by a ringing "Heigh Ho Silver."

At the end of our walk a fire and more nourishment were very welcome. By the time the remaining (we thought) stragglers had found the haven, the *Nereis* was waiting. As the last dinghy delivered its load, two figures were silhouetted on the horizon and Armstrong and Jones were saved from a night with the ticks. They pleaded a wrong turn in the road—we saw the same mermaids.

Our outing came to an end with another feed at the laboratory and, Thursday, watermelon at 4:00.

"May we also submit a short ditty
In praise of our super committee
In thanks for the fun
And all you have done
To make our picnic so snifty!"

—W. E. H.

TEMPERATURE IN EVOLUTION AS SHOWN BY STUDIES ON DROSOPHILA

DR. H. H. PLOUGH

*Professor of Biology, Amherst College**(Continued from last issue)*

There is one other aspect of the relation between temperature and the mutation process. Heat could affect the mutation process by the production of specific mutations. If any such should occur with a sufficiently high frequency they might conceivably influence the course of evolutionary change by mutation pressure regardless of any selective advantage. Some years ago Jollos believed that he had secured evidence of just such a process, which he suggested furnished a basis for explaining cases of orthogenetic evolution. Among the offspring of flies treated with high temperature he found several mutations, especially a dark body and a lighter eye color. When offspring of these were heated in several generations in succession he isolated a series of darker and darker body color, and lighter and lighter eyes, eventually securing an ebony body and a white eye. These results have never been confirmed by other investigators. Ives and I examined for visible mutations many thousands of flies derived from heated parents, and found many mutations, but they never showed any correspondence from one generation to the next. Their number has never been sufficiently great to admit of the possibility of significant mutation pressure. Heat acts to increase all types of mutations, and no conclusive evidence exists that it has any differential action of significance for evolution.

In his observations on the production of what he has called *Dauermodifikationen* following treatment with high temperature, Jollos is receiving partial support in work at the Amherst Laboratory. In 1931 and 1933 Jollos reported the appearance among the offspring of heated parents of several phenotypic characters like dwarf flies, aeroplane wings, crumpled wings, and abnormal abdomen. When pairs of individuals showing these characters were mated together, a certain number of their unheated offspring also showed the characters, though there was no evidence of genetic segregation. Instead the characters appeared as though determined by cytoplasmic inheritance, as in Jollos' well known cases in protozoa. Such phenotypic characters progressively diminished in numbers after one or two further untreated generations and eventually (F_5 in the most extreme case) disappeared entirely. Since some of these modifications resembled known mutations, however, and since one or more such mutations appeared among their offspring, Jollos expressed the belief that the genes and the materials in the cytoplasm on which they normally

act were affected in the same way by heat treatment. Just, following Jollos' suggestion, has gone even further and stated that this work gives evidence that the cytoplasm is primarily affected by environmental agents and that this in turn acts on the genes in the nucleus to produce mutations.

Interesting as such a suggestion is, it goes far beyond the experimental evidence. It has been our experience repeated many times, that temperature shocks repeated in successive generations cause a cumulative diminution in fertility. In all such lines fewer and fewer offspring hatch until eventually the lines die out, although unheated controls remain healthy. Ives and I in the study cited above, (1935) observed a marked increase in somatic modifications among the offspring of heated females, but none among those of males, thus suggesting a direct cytoplasmic influence. We found also that this excess in the number of non-specific modifications persisted for several generations. Thus there seemed to be a "carry-over effect" of the heat treatment on the cytoplasm. In our cultures, however, there was little tendency, for the same modification to appear in succeeding generations but only a general tendency to throw a series of modifications.

This carry over effect has interested us and we have searched for cases in which it would be possible to demonstrate it beyond question. Such an indubitable case has now been analysed by Child which he allows me to cite in advance of publication. Child and Albertowicz found that growth of vestigial larvae on food containing an excess (0.1% to 1.0%) of nipagin, the chemical so widely used for preventing mold growth in cultures, gave a great increase in vestigial wing area. Child soon showed that this result was not a specific chemical effect, but was simply the result of starvation and a lengthening of the larval period. The nipagin also reduces the growth of yeast on which the larvae feed. He has now added the further unequivocal proof that the increase in wing size persists in untreated F_1 offspring of this generation both through the female and the male line. This gives the first quantitative demonstration of the non-genic inheritance of an environmentally induced character, or a *Dauermodifikation*. There is no evidence of a genetic change, and the effect may be expected to disappear. The work does emphasize however, that non-genetic modifications induced by external agents like temperature may have importance in the automatic selective processes of evolution be-

yond the generation immediately acted on.

We come finally to our third main subdivision, i.e., the influence of temperature on the composition of wild populations. The mathematical ground work for an understanding of the automatic genetic processes determining evolutionary change has been laid down by Fisher, Haldane, and especially Wright. Fisher and Haldane have concerned themselves with the rate of change expected in natural populations due to selection of single mutation possessing any specific degree of advantage. Haldane illustrates the different rates at which a population would change in respect to a character which has a 0.1% advantage (i.e. 1000 of the favored type to 999 of an allele) for three common Mendelian substitutions. It will be noted that a slight increase in the frequency of any particular mutation (of the order of the temperature effect) would make little change in the end result. Wright has undertaken the much more difficult task of estimating the situation where multiple gene frequencies are considered. He has analysed mathematically the effects on populations of different sizes of different rates of mutation, different coefficients of selection, and various degrees of inbreeding. His conclusions are that the most favorable population for evolutionary change is one more or less subdivided into many partially isolated subdivisions, in each of which there is close to an equilibrium between all the following factors: a moderate rate of mutation, moderate selection and elimination, and a certain ratio of inbreeding. The advantage of such a mathematical statement of conditions is that it can be checked by analyses of populations in the wild. Assuming that about the same mutations occur in a *Drosophila* population wherever found, the composition of the population would be influenced by environment—which would determine population size, and the population size would determine the amount of inbreeding. Thus in a large freely interbreeding population all gene frequencies would tend to approach equilibrium with minor peaks here and there where certain groups of characters are slightly in excess (A). Secular changes like high or low temperature would tend to subdivide the population into many partially isolated groups where random divergencies would make for continuous change by intergroup selection (B), thus giving a more favorable condition for continuous evolutionary change. Finally excessive high or low temperatures—like the freezing temperatures of winter—would eliminate large numbers of the population leaving small completely isolated groups (C). In these communities of a few individuals the automatic processes would rapidly result in fixing of random combinations at dead levels. Such predictions may be checked by the

collection of samples from various wild populations and the use of tests, by the methods already outlined, of the numbers of lethals or other mutations found.

In a large freely interbreeding population (A) we should expect a moderate number of different mutations, which change from year to year, though some would persist. This is exactly what Dubinin and his co-workers have found in their laborious investigations on the wild *Drosophila* populations of Gelendzhik in Russia.

In populations partially isolated into small but communicating groups (B) we should expect each group to possess a small number of different mutations, visible and lethal. Spencer has demonstrated exactly this situation in his analysis of several races of *Drosophila hydei*. Finally Ives and I appear to have discovered two cases of (C) small groups isolated by freezing temperatures, which may or may not be joined in midsummer. Last fall I collected a culture of *Drosophila melanogaster* at Belfast on the coast of Maine. At about the same time Ives collected more than 150 separate wild males from South Amherst, Mass. We analysed these for second chromosome lethals with the surprising result shown in Table 2. Each of these two new England wild stocks showed nearly 50% of all the chromosomes tested to be carrying lethal genes. These lethals are still being tested for identity and location by Ives. The total number of different lethals in the Belfast stock is not large,

TABLE II.
Chromosome II lethals in wild populations

	Total Chromosomes Tested	Lethals Found	Percentage of Lethals
Florida \$10 1937 (laboratory strain)	223	12	5.4
Lausanne stock 1938 (laboratory strain)	81	0	0.0
Belfast, Me. 1938 (F ₁ offspring of 6 pairs)	115	51	44.3
So. Amherst 1938 (Separate wild ♂ ♂)	151	65	43.1
<i>Dubinina</i> 1936			
Gelendzhik, Russia			
1933	877	70	07.98
1934	616	78	12.66
1935	797	70	08.78

while most of them are different in the South Amherst population. The results may be profitably compared with the ratios shown by other stocks. Dubinin's stocks appear to fall in group A or B above, while our wild populations are definitely in group C. In the Lausanne stock, which Bridges showed to have entirely normal salivaries, no lethals were found even after many generations of inbreeding.

Thus we seem to have added some weight to Wright's analysis, and to have given some experimental proof of what is perhaps the most important activity of temperature in evolution, namely that it is a secular agent which periodically reduces large populations to small ones. In such small groups lethals and other mutations accumulate to high levels. If several such populations join together in the summer a rapid overturn of equilibrium occurs, with the possibility of speeding the process of evolutionary change.

To summarize then, our investigations at Am-

herst on the effects of temperature on genetic processes aid in an understanding of the ways in which evolutionary processes in nature are kept going. First, high temperature during development tends to accentuate the expression of mutant characters, and so speeds up the process of selection. Second, mutation frequency is increased both by higher temperatures and by temperature shocks. This raises the genetic variance and increases the rate of the automatic process of selection without changing its character. Third, high and low temperatures act as secular agents in breaking up large populations in approximate equilibrium into smaller groups in which different gene frequencies reach peak levels. Such situations appear to be more favorable for continuous evolutionary change.

(This article is based upon a lecture entitled "The Influence of Temperature in Evolution as Shown by Genetic Studies in *Drosophila*," given at the Marine Biological Laboratory on June 30.)

RECENT CRUISES OF THE "ATLANTIS"

(Continued from page 29)

for the first half of this voyage consisted of Dr. H. R. Seiwel (in charge), Dr. Henry Mahncke, Mr. Alfred Woodcock, Mr. Dean Bumpus, Mr. Andrew Stergion and Mr. Lambert Knight. On the way south the routine Gulf Stream observations were made and then the *Atlantis* proceeded to the western part of the Northern Equatorial Current. In a triangular area, roughly 600 miles on a side, a close network of hydrographic stations was occupied. This survey was one of the most intensive ever carried out in the tropical Atlantic and will be used both for a study of the origin of the oxygen minimum layer and to test out the new principles of lateral mixing which have recently been introduced into oceanography from dynamic meteorology.

After being out some 34 days from Bermuda, the *Atlantis* put in at Martinique to reprovision and to give the crew a rest. Since a carnival was in progress at Fort de France, the latter objective was hardly achieved. She sailed again on February 24 and headed for the Windward Passage.

On the first leg of the voyage two anchor stations in deep water had been occupied. Between Martinique and the Windward Passage several more were attempted. Trouble was experienced with the wire kinking on the bottom and several anchors were lost, but not before some useful data on short period internal waves had been obtained. The ship put in at the American naval base at Guantanamo to secure additional anchors and proceed to Havana where she arrived on March 17.

Mr. William Schroeder then joined the *Atlantis* to take charge of the scientific work for the next

leg of the voyage. He was accompanied by Dr. Luis Howell Rivero of Havana University. Dr. Seiwel, Mr. Stergion and Mr. Knight returned to Woods Hole. There followed seven weeks of deep sea dredging in which the Museum of Comparative Zoology and Havana University shared the expense and the catch. As in the previous winter, Cuba was circumnavigated and short stops were made at several of the convenient ports. Under Mr. Schroeder's direction, the success of this dredging area even surpassed the work of the previous year when over 1000 species were collected, of which about 100 were new.

On May 15 the *Atlantis* finally headed for home. On the way north the Gulf Stream stations were reoccupied and some physiological observations were collected by Dr. Gordon A. Riley of Yale University. On June 3 the ship docked at Woods Hole, having sailed approximately 10,500 miles and having been away just five months. During June the standing rigging on the mainmast was replaced and the ship's bottom was repainted. On July 5 she sailed again to repeat the observations on the strength of the Gulf Stream.

The National Cancer Research Foundation has awarded \$1,500 to be spent for research on cancer at Washington Square College of New York University under the direction of Robert Chambers. He has also received a grant from the Rockefeller Foundation for \$1,250 for research in cellular physiology.

The A. B. C. of Woods Hole for 1939

All Schedules Set to Daylight Saving Time — Bold Type Indicates P. M.

POST OFFICE

	Week Days	Sundays
Lobby open	7:00 to 7:50	10:30 to 5:30
Window Service	7:30 to 6:00	Not Open
Mails Arrive	6:50, 10:45, 3:35, 6:55	10:45
Mails Ready	8:00, 11:30, 4:15, 7:15	11:30
Mails Close	6:30, 10:00, 5:10	5:30

BUS SCHEDULE

Falmouth — Woods Hole*

	Daily	Daily
Falmouth (Leave)	10:26	3:31
Woods Hole (Due)	10:35	3:40
	Daily	Daily
Woods Hole (Leave)	10:50	5:40
Falmouth (Due)	10:58	5:48

*Discontinued after September 9.

RELIGIOUS SERVICES

Church of the Messiah (Episcopal)

Sundays: 8:00 Holy Communion; 11:00 Morning Prayer (Choral Eucharist, first Sunday in the month).
Holy Days: 8:00 Holy Communion.

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Morning Worship, 11:00. Church School, 10:00.

First Orthodox Congregational Church

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Sundays
9:00 to 11:00
4:00 to 6:00

TRAIN SCHEDULE*

	Ex. Sun.	Ex. Sun.	Ex. Sun.†	Daily	Sun. Only‡	
Woods Hole	7:15	10:30	12:35	6:00	7:55	
Boston	9:10	12:50	2:30	8:10	9:55	
	Ex. Sun.	Sun. Only	Sat. Only	Ex. Sun.†	Ex. Sat. & Sun.	Ex. Sun.
Boston	8:20	8:35	1:00	1:30	4:00	4:48
Woods Hole	10:45	10:45	3:00	3:44	5:55	6:55

* All Trains stop at Falmouth.

† Does not run Labor Day.

‡ Runs also Labor Day.

BOAT SCHEDULE*

Leaves	Daily	Daily	Weekdays†	Daily	Weekdays‡	Fri. Only	Fri. Only‡
New Bedford	7:00	9:30	2:30	2:30	....	7:30	....
Woods Hole	8:30	10:50	3:50	3:50	7:00	8:45	9:30
Oak Bluffs	9:20	11:40	....	4:50	....	....	10:15
Vineyard Haven	....	....	4:50	....	7:40	9:30	....
Nantucket	11:35	2:00	....	7:00	....	....	12:15
(due)							
Leaves	Weekdays	Daily	Sun Only||	Daily	Weekdays‡	Daily	Sun. Only||
Nantucket	....	7:00	2:00	2:30	....	5:00	....
Vineyard Haven	6:10	....	....	....	6:00	....	....
Oak Bluffs	....	9:15	4:00	4:30	....	7:00	9:00
Woods Hole	6:55	10:15	5:00	5:30	6:45	7:45	9:45¶
New B'df'd (due)	8:10	11:30	....	6:45	....	9:00	....

* Schedule effective to September 7, incl.

† Discontinued after September 2.

‡ Will not run Labor Day.

§ After September 1 terminates at Vineyard Haven.

|| Discontinued after August 27, but runs Labor Day.

¶ Leaves Woods Hole 9:45, due Vineyard Haven, 10:30.



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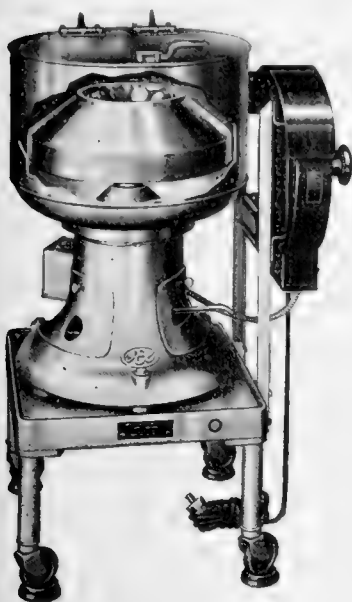
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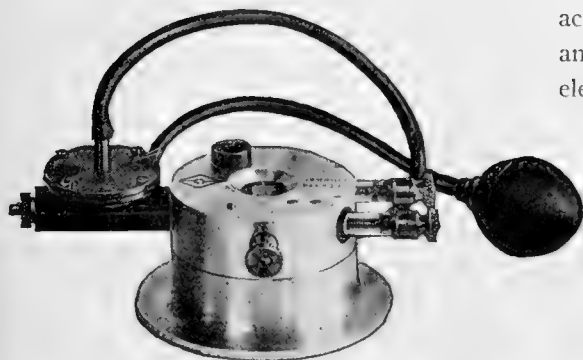


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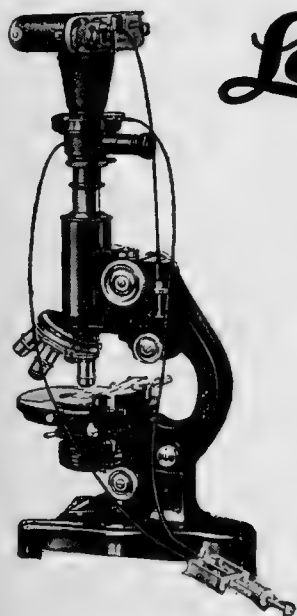
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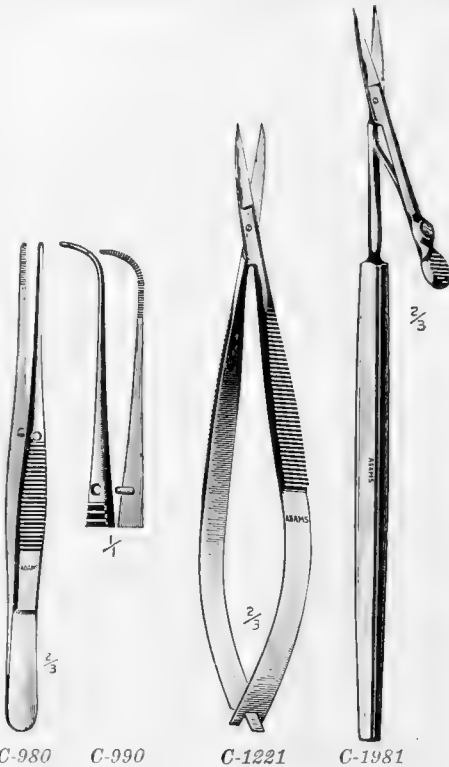
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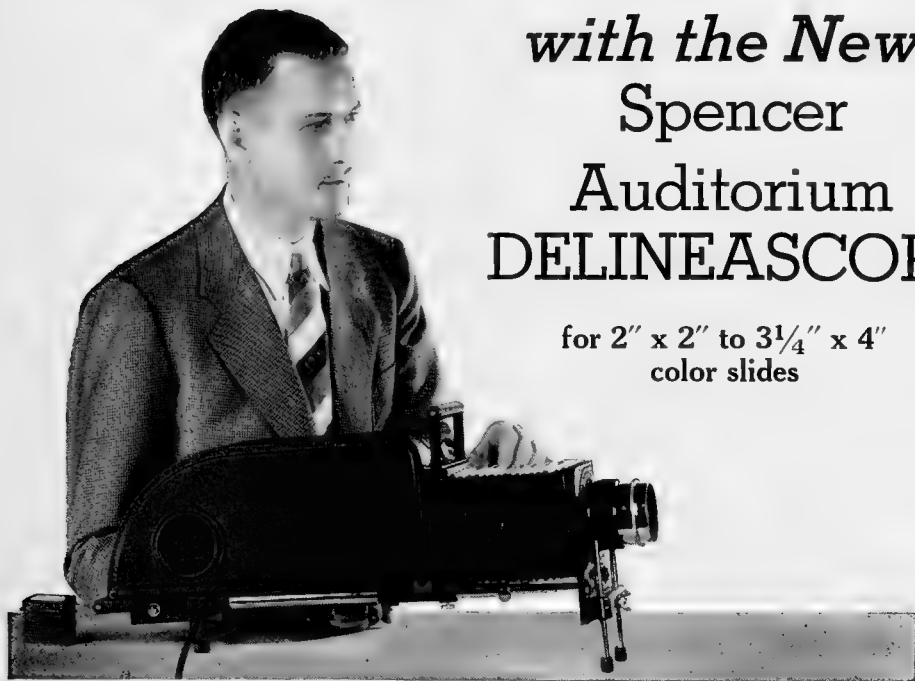
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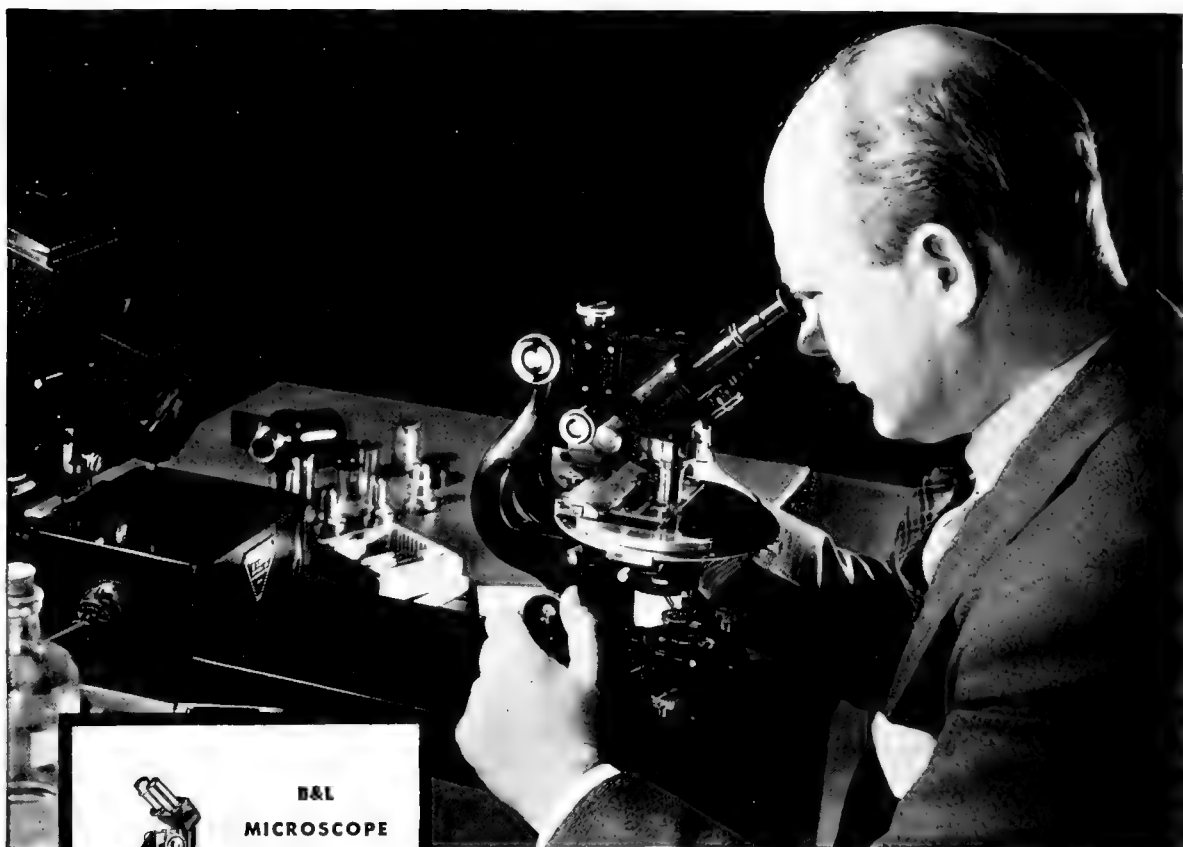
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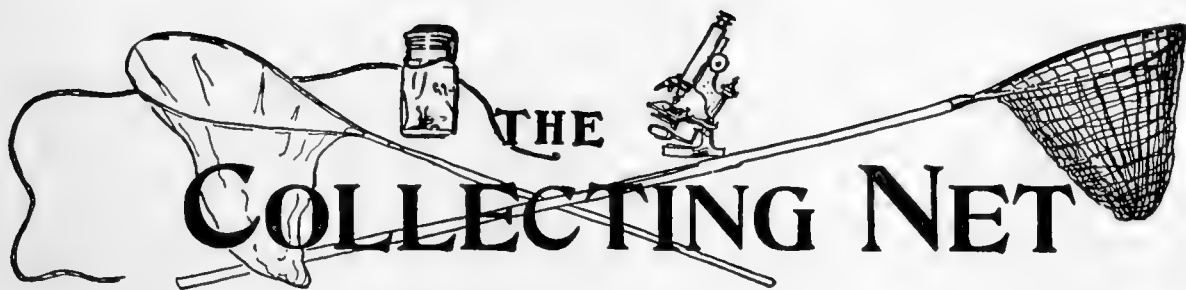
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Vol. XIV, No. 3

SATURDAY, JULY 22, 1939

Annual Subscription, \$2.00
Single Copies, 30 Cents.**NEURAL DIFFERENTIATION WITHOUT ORGANIZER**

DR. L. G. BARTH

*Assistant Professor of Zoology,
Columbia University*

Previous experiments have shown that the amphibian ectoderm in the gastrula stage may very easily be stimulated to form a neural plate. This suggested that under certain conditions the ectoderm might form neural plate without the organizer or any external stimulus. It was first found that the fusion of two to eight explants of ectoderm would develop into neural tubes, while a single explant formed only a mass of epidermis.

Following this a number of fusions between two pieces were made, some with the antero-posterior axis coincident and some reversed. When the antero-posterior axis of the two explants coincides a neural tube differentiates, but when the axes are reversed only epidermis results. Thus the polarity of explants must be preserved in order that a neural tube may form without an organizer.

The neural tube dif- (Continued on page 64)

CELLULAR ACTIVITY RELEASED BY ORGANIC COMPOUNDS IN SURFACE REACTIONS

DR. RUDOLF HÖBER

*Professor of Physiology,
University of Pennsylvania*

In 1855 the botanist, Karl Naegeli, published his *Pflanzenphysiologische Untersuchungen* about plasmolysis, and in 1867 Moritz Traube published his model studies on precipitation membranes. Since then, the discussions about structure and properties of the cell surface have been endless. The ardent interest in this problem captivated all kinds of investigators: those who, following their mental disposition, prefer to build up physiology from below and therefore tie up their work to physical and physico-chemical models—as did and do Wilhelm Ostwald, Bernstein, Collander, Michaelis, Overton, Ralph Lillie, Newton Harvey, Langmuir and Rideal—and those who are more impressed by the classical trend of the physiology

from above. The latter investigators may particularly refer to Overton who, more deliberate than others, made a distinction between what I have

M. B. I. Calendar**TUESDAY, July 25, 8:00 P. M.****Seminar:** Dr. David R. Goddard, "The Relation between Fermentation and Respiration in Higher Plants (The Pasteur Effect.)"

Dr. Claude ZoBell, "The Role of Bacteria in the Fouling of Submerged Surfaces."

Dr. Edmond W. Sinnott, "Cell Division and Differentiation in Living Plant Meristems."

FRIDAY, July 28, 8:00 P. M.**Lecture:** Dr. Viktor Hamburger: "Correlations between Nervous and Non-nervous Structures during Development."**TABLE OF CONTENTS**

Cellular Activity Released by Organic Compounds in Surface Reactions, Dr. R. Höber	53
Neural Differentiation without Organizer, Dr. L. G. Barth	53
Differentiation of Isolated Rudiments of the Amblystoma punctatum Embryo, Dr. Floyd Moser	62

Production of Duplicitas Cruciata and Multiple Heads by Regeneration in Planaria, Mr. Robert H. Silber	63
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THE MARINE BIOLOGICAL LABORATORY

called the physical permeability and the physiological permeability of the cell surface, describing the latter one by the term of adenoid activity. It was his intention to make the clear statement that the cell surface often appears to be more than a membrane in the sense of physics and physical chemistry, because often an active part in the transport and import as well as export of substances, particularly a transport against concentration gradients, has to be claimed. This is frequently observed in adenoid tissue (as it is in glands) but, much more generally, perhaps universally, in different degrees and at different times it may be met in each cell. Active transport is really a general phenomenon of life, a criterion of life, as are metabolism, respiration, growth, development and excitability. This means that in any case the structure of the physiological surface is indefinitely more complex than a model, which imitates chiefly one or a few features of the physiological surface. This has become clearer and clearer as evidence was gained that proteins, phosphatides, sterols, enzymes and co-enzymes participate in the organization of the cell surface or—we may even say—in the life of the cell surface. Also you may now recall the amazing and vigorous movement in the cell surface, as revealed in the brilliant motion pictures of Carrel, Fauré-Frémiet and Chambers.

My plan is to discuss recent experiments concerning the interrelation between organic compounds and cellular surfaces involved in active transport.

Let me begin to describe a series of experiments dealing with an old and well known procedure to localize and analyze transport activity. The favored subject for this purpose has often been the amphibian kidney, particularly the isolated frog's kidney perfused with Ringer's solution. For there is no other organ which, by the variety of the localization, of the direction and probably of the mechanism of transport is more adapted to perform osmotic work than the kidney and, in order to study these manifestations of the small surviving organ which is the frog's kidney, for many years it has seemed to me promising to apply an old tool of kidney physiology, dyestuffs. According to the special anatomy of the amphibian kidney, perfusing this organ with dyestuff solutions only through the aorta reveals information about the filter-like properties of the glomeruli. Perfusing it through the renal portal vein reveals whether there comes into play a secretory trans-

porting activity in the epithelial layer of the proximal tubules, as indicated by an increase in dyestuff concentration. This is easily seen in the color intensity of the secretion, although, in general, no more than two to three ml. per hour of secretion are obtained from the capillary catheters inserted in the ureters.

Experience obtained during many years with numerous dyestuffs gave the result that, if the kidney after being perfused through both vessels with dyestuff Ringer's yields a colorless secretion, the dyestuff has colloidal properties. In this respect our preparations support the conclusions, mainly drawn from various kinds of investigations by Richards, that the kidney, especially the glomerulus, behaves like a common ultra-filter. On the other hand, a dyestuff which is markedly diffusible and is enabled for this reason to pass a diffusion membrane, e.g., a cellophane membrane, and which is introduced into our preparation through the arterial side only, appears in the secretion. Much more interesting are those dyestuff experiments which reveal the highly selective properties of the tubular walls. Well diffusible dyestuffs, after being introduced only through the renal portal vein, may appear in the secretion or they may not, and whenever they appear, they do so 5 to 10, up to 75 times concentrated. This is comparable to the behavior of the kidney under physiological conditions, where its mysterious selective activity is evident as shown, for instance, by the accumulation in the secretion of urea or of uric acid, these being selected from numerous components of the blood. Here, by a systematic study of dyes, which are provided by the technical laboratories in hundreds of variations, we may try to approach the problem of selective reaction of the cells and of selective transport. Of course, selective reactions of dyestuffs with cells have been a fascinating problem for a long time (as we know, for instance, about the specific, therapeutic value of methylene blue), and the solution of this problem seemed to be pushed forward to an endpoint about 30 years ago, when Paul Ehrlich discovered the specific, chemotherapeutic effects of extremely small amounts of trypan blue, trypaflavin and related dyes on trypanosomes. Now, what kind of chemical or physico-chemical properties might be responsible for the selective behavior of the kidney?

Some years ago I studied the secretory ability of the frog's kidney on five benzene-azo-naphthalene-sulfonates (Fig. 1). The result was that

Azofuchsines I-V

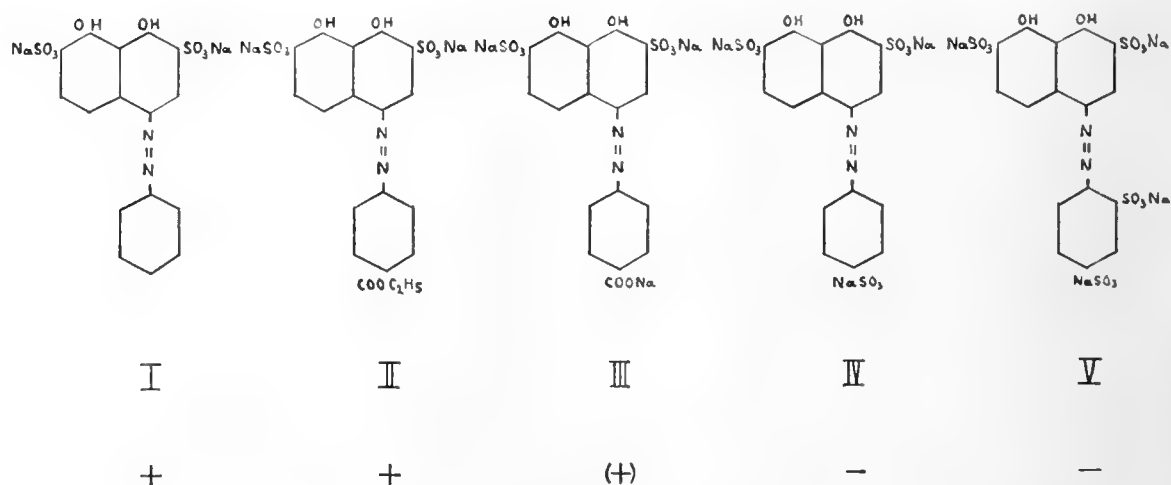


FIGURE 1

number I and II are secreted, as indicated by a +, number IV and V are not, indicated by —, and III takes an intermediary position. This would be indicative of a special function of the sulfonate group, and the following explanation seemed to be adequate. The five dyestuffs have a polar-nonpolar molecular configuration, two halves being linked together by an azo group. I and II, which are selected by the kidney for accumulation in the secretion, are provided with a hydrophilic half, characterized by the attachment of the two polar sulfonate groups, and with a hydrophobic, organophilic half which is non-polar in character, whereas IV and V are composed of two hydrophilic halves. This is suggestive of the concept that a first step in the secretory process, which is certainly a complex phenomenon, would be the attachment of the dye to the cell surface like in a Langmuir film, where the hydrophilic heads—say, those of the molecules of a fatty acid—are turned to the

aqueous phase, whereas the hydrophobic organophilic tails are oriented to the other side, in this case the cell body.

Now, recently, in collaboration with Miss Priscilla Briscoe, I have begun to look for and to test dyestuffs, whose behavior would be in agreement with this hypothesis. You see here (Fig. 2) a scheme of 7 benzene-azo-naphthalene-mono-sulfonates, the location of the sulfonate groups being indicated by the small circles. All of them are concentrated by the kidney. Furthermore, here are 7 benzene-azo-naphthalene disulfonates. Four of them are concentrated, three are not. You see immediately that only those compounds which have a polar-nonpolar molecular configuration fulfill the conditions for passage: they seem to be fixed by the secretory epithelial structure, whereas when both halves of the molecule are occupied by sulfonates, the ability of the dye molecule to anchor on the cell surface is abolished.

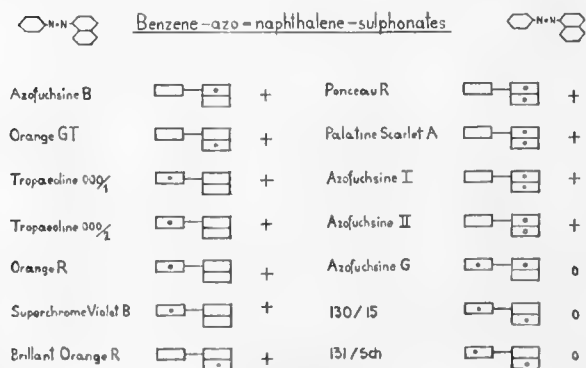


FIGURE 2

Evidently, so far, we have to conclude that in this series of benzene-azo-naphthalene sulfonates, the location of the sulfonates is the decisive factor in determining the functional connection between cell and substrate. Certainly, in a more careful investigation with those dyestuffs which undergo secretion, we will find quantitative differences due to the particular place in the ring where the sulfonates are located, or due to the presence of other radicals like OH, or NH₂ and others. As a matter of fact, we have already noticed that doubling the number of sulfonates in one half of the molecule increases the polar-nonpolar character of the dye and therefore the ability to pass the tubules. For instance, take two benzene-azo-

naphthalene sulfonates, Ponceau R and Brilliant Orange R, both of them having two methyl groups attached on the benzene ring in the same position, both of them possessing an OH group in the naphthalene ring, but one with one sulfonate, the other with two. The same kidney, alternately perfused with the two dyestuffs, gives a concentration 15 times higher than in the perfusion fluid with Brilliant Orange, 50 times higher with Ponceau R. We shall come back to this point later.

Another group of our experiments was concerned with 11 naphthalene-azo-naphthalene-disulfonates. The results have been listed in the adjoining table (Fig. 3). You see that the six dyestuffs listed on the left side are secreted: they are characterized by bearing the two sulfonates on one naphthalene ring. On the right side you see five dyestuffs, among them one black sheep, Crocein Scarlet 3BX. Four are all right insofar as they conform to the theory, the two sulfonates being attached to the opposite halves of the molecule. Whether, further on, we may be able to wash the black sheep to white, we do not know at present. One possibility may be the following: only in Crocein Scarlet 3BX, this sulfonate group in one naphthalene ring is located in the so-called peri position. It would be worth trying to find out whether the hydrophilic value of this sulfonate group is invalidated by its location.

During the last weeks we have extended our investigations to other groups of dyestuffs, one group consisting of the disazo dyestuffs in some way resembling the azo dyestuffs, another group comprising a number of triphenylmethanes, this particularly well-known group of colors, including, for instance, substances such as Rosinduline, Methyl Violet, Anilinblue, Acid Fuchsin and others. With respect to the disazos we cannot say more than that here too the physiological behavior seems to be determined by the polar-nonpolar configuration of the molecule.

Such a characteristic configuration is entirely lacking in the triphenylmethane sulfonates. This may be why, up to the present time, we have not found any of them, which, when offered to the tubular wall, would be allowed to pass.

Now I have to turn your attention to a rather puzzling phenomenon, to an unexpected limitation of the results so far related. These results are valid only with regard to the Ringer perfused kidney. The Ringer solution appears to wash out a part of the normal secretory properties of the kidney. It looks like two mechanisms normally being active in the tubules, one more labile than the other. This follows from our observations that the frog kidney, when excised from the body and simply put into the oxygenated dye solution, is able to collect all the dyestuffs mentioned, so that

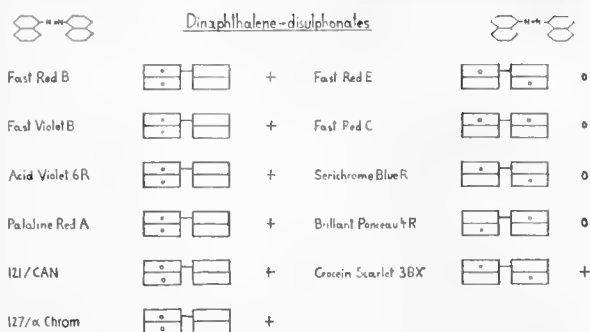


FIGURE 3

they appear under the microscope concentrated in the lumina of the tubules, azo dyes as well as triphenylmethanes.

This phenomenon, so startling at first, is, on second thought, not so surprising. At first, there is no doubt that different independent mechanisms for osmotic work are active in the kidney. For instance, from experiments of Marshall and Crane and from our own experiments it is known that urea, before being excreted in the frog's kidney, is stored by some linkage in the tubules, particularly on the dorsal side, i.e., in the proximal tubules. Secondly, the washing out effect reminds one of an interesting finding of A. G. Clark, published in 1913, which refers to the so-called hypodynamic state of the frog's heart. This state appears after a prolonged perfusion of the heart with Ringer's, and it means that the activity of the heart fades slowly during the course of the experiment. Here, in reality, the effect is due to the washing out of a substance, since the activity is regained after the addition to the perfusing Ringer of very minute amounts of higher fatty acids or of lecithin.

It is finally worth mentioning the fact that from a fairly great number of dyes tested in our experiments the excised kidney concentrates all but four dyes, these containing four to five sulfonate groups, but being well diffusible. I shall come back to this statement in a few minutes.

Now I am going to turn your attention to another subject for investigating dye secretion which displays a remarkably different behavior. This subject is the isolated, Ringer perfused frog's liver. It differs from the Ringer perfused kidney in two main points. First, the dyestuff introduced in a very slight concentration, generally not more than 0.0005%, reappears in the bile duct, not 10 to 75 times concentrated as in the corresponding experiments in the kidney, but some 100 and often several thousands of times concentrated. The second point is this: the Ringer perfused liver does not behave like the Ringer perfused kidney, but like the excised kidney. In other words, ex-

TABLE 1

Dyestuff Concentration Compared with that of Inulin

Dyestuff Concentration Factor	Inulin	
	p.c. in perfusion fluid	p.c. in secretion
70	0.069	0.049
45	0.069	0.068
60	0.040	0.037
30	0.040	0.041
40	0.064	0.053

cept for the highly colloidal and except for the poly-sulfonate ones, all dyestuffs appear in the secretion. This would allow the following interpretation: first, adsorption in the cell body, which may be a conditioning factor in the complex phenomenon of dyestuff secretion, will be prevented by piling up the number of hydrophilic groups in the dye molecules and strengthening in this way the force resisting anchorage in the cell body. Secondly, the secretory mechanism in the liver is more resistant to Ringer perfusion than in the kidney, where perfusion abolishes a part of the binding properties.

Until now I have talked mainly about the general conditions warranting the uptake of dyestuffs by the liver. Let us now proceed with the discussion of some possibilities of gaining information on the properties of the unknown working machinery. One way of doing this was to replace in the perfusion fluid the dyestuffs by other substances in order to learn which general properties of the dyestuffs are responsible to their being con-

centrated to such a high degree. The other way, which was found to be full of barriers, was to change the structure of the machinery by adding to the perfusion fluid certain active substances.

In the first way, we obtained the following results: the dyestuffs seem to be specifically apt to be accumulated in the secretion. It has already been mentioned that adsorbability seems to be a factor in dyestuff transport, because only those dyes fail to appear in the liver secretion which are poly-sulfonates and for this reason particularly organophobic and hydrophilic. On the other hand, in studies which have been performed in our laboratory by Dr. Haywood, it appeared that substances which lack adsorbability, such as xylose, glucose, lactose, inulin, magnesium ion and probably amino acids pass the frog's liver like a passive filter, in other words, they reappear in the secretion in the same concentration as that in the perfusion fluid. Table 1 illustrates this behavior in experiments where inulin was provided to a frog's liver.

In our second approach to analyze the secretory mechanism, we added to the perfusing dyestuff Ringer solution, as already mentioned, substances which are apt to alter the working machinery. It has been known for a long time that bile salts are the most effective cholagogues. This means agents which promote bile secretion. Why? I have tried to answer this question, particularly in collaboration with Dr. E. Moore, by looking for substances which show the opposite effect. Such an inhibitory effect appeared to be easily, intensely and reversibly demonstrated. Much more difficulty was met with the other problem of finding promoting substances, because substances of such a nature are toxic beyond some limiting concentration and beyond some time interval of attack, toxic in a

TABLE 2

Dyestuff Secretion of the Liver

<i>inhibited by</i>		<i>promoted by</i>	
sucrose	asparagin	glycocholate	(acetamide)
maltose	malonamide	taurocholate	(urea)
fructose	succinamide	oleate	phenylurea
mannose	gluconate	laurate	phenylcarbamate
xylose	aspartate	heptylate	propylcarbamate
arabinose	glutarate	caprylate	propylalcohol
mannitol	succinate	capronate	codein
adonitol	malonate	salicylate	veratrin
erythritol	lactate	toluenesulfonate	digitonin
glycerol	pyruvate	benzenesulfonate	saponin
(ethylenglycol)	(glycolate)		
glycin			

TABLE 3
Anticholeretic and Choleretic Effects

Sodium Salts	Molarity	Dyestuff Concentration Factor			Amount of Secretion τ /hour		
		Before	During	After	Before	During	After
Acetate	0.028	40	0	16	0.63	—	27
Glycolate	0.014	600	200	770	17	6.3	27
Glutarate	0.028	730	6	250	54	0.091	9.9
Malate	0.028	260	30	210	16	0.18	11
Succinate	0.028	630	6	120	36	0.41	4.5
Taurocholate	30×10^{-5}	1000	3200	950	16	180	15
	170×10^{-5}	1146	641	193	46	167	134
Oleate	5×10^{-6}	730	900	580	48	58	32
Salicylate	7×10^{-5}	150	280	—	70	120	—

way such as bile salts themselves can be toxic. For this reason, many experimental failures seemed to be unavoidable.

According to their effects, the organic compounds which have been studied can be grouped as in Table 2.

It is at once evident that these compounds, which physiologically appear to be related to each other, belong chemically to very diverse groups. This is similar to the situation obtained by Overton in trying to establish a theory of narcosis. With this goal in mind he travelled through many fields of organic chemistry looking for substances which display a greater or a smaller or at least a trace of anaesthetizing power and landed thus at the fact that the physiologically related, but chemically unrelated compounds are characterized by more or less marked lipid solubility, as he has called it. In our table you see listed on one side substances exhibiting an inhibitory effect, on the other side substances exhibiting a promoting effect with regard to liver secretion. On one side, you see that the sugars have been placed with polyhydric alcohols, amino acids, some acid amides and hydroxyl carboxylic acids. On the other side, the salts of the bile acids have been placed with those of the higher fatty acids, of aromatic carboxylic and sulfonic acids, of alkaloids and sterols, and, as in Overton's work, instead of chemical properties one finds physico-chemical ones, which are common to the members of each group. The inhibitory substances, on one hand, are surface inactive. Their chemical structure, particularly with the multitude of OH groups, displays their hydro-affinity. Therefore they compete with hydrophilic colloids for the water dipoles and exhibit an anti-dispersing, a shrinking or condensing effect evident, for instance, by an increase in

turbidity of an emulsion of lecithin, of starch or of gelatin. On the other hand, the promoting substances are surface active. Some of them have a polar-nonpolar molecular configuration, with their organophilic tail anchoring at organic surfaces, while their hydrophilic head pulls towards the water and brings about a dispersing, a loosening and a disintegrating effect. Others are nonpolar and are lipid soluble and, after being adsorbed to the organic surface, they are able to diminish the lateral adhesion forces between the molecules of the organic surface and can exhibit, in this way, a loosening effect.

This loosening effect by agents of various chemical groups is well known in cell physiology as cytolysis. Jacques Loeb, particularly in his famous experiments on artificial parthenogenesis, which he performed here in Woods Hole more than 30 years ago, discovered the fact that the activation of the unfertilized egg could be started by small amounts of bile salts, soaps, higher fatty acids, starting with heptylic acid, and by alcohol, ether, benzene or amylene, but that, instead of activation, disintegration and cytolysis were the result when these agents were applied either in too high a concentration or when the experiments were run too long. This is comparable to the general outcome of our experiments with the promoting compounds.

The physico-chemical properties of the promoting group appear to be opposed to those of the inhibitory group. Table 3 shows some samples of this different effect. This suggests trying to find out whether an inhibitory substance could be balanced by the addition of a promoting one and this is, in fact, possible. In general, the inhibitory effect could be demonstrated in the following manner: 1/8 of the sodium chloride contained in the

TABLE 4
Antagonistic Effect of Inhibiting and Promoting Substances

	conc. ratio	dye secreted mg/hour $\times 10^4$
Ringer	99	10
" + 1/8 isot. sucrose	0	0
" + " + $8 \cdot 10^{-6}$ mol. taurocholate	364	130
Ringer	165	25
" + 1/8 isot. glucose	11	4.5
" + " + 1/8 isot. urea	250	50

perfusing Ringer solution is replaced by the isosmotic amount of one of the members of the inhibitory group, for instance by mannitol. After a short time the rate of secretion drops and the dye concentration fades, frequently down to 0. After rearranging the initial conditions, the dye reappears and the rate increases. Table IV illustrates the course of two experiments concerning the antagonism between an inhibitory and a promoting substance. I imagine these results will remind you of the innumerable experiments on the physiological antagonism of monovalent and polyvalent cations, for instance the antagonism between a high concentration of sodium and a low concentration of calcium or a high concentration of magnesium and a high concentration of calcium.

This parallelism makes one ask whether both group phenomena could not be interpreted in a corresponding manner. This would mean considering them as alterations of permeability due to colloidal processes located in the surface structure of the cells, in one case exhibited by ions, in the other by organic compounds. Of course, agreeing to such an interpretation does not mean more than a very vague approach to a final understanding of a very complicated phenomenon. However, taking into account that with the influence of the promoting substances we are dealing with an activation of the secretory process, it seems to be of some interest that the same group of organic compounds, which have been found to display the symptoms of higher activity in the liver, have been found to release changes in muscle and nerve which resemble the physical manifestations of excitation. It is an old concept, advanced more than 30 years ago in connection with Bernstein's theory of the normal polarization of the surface of muscle and nerve fibers, that the negativity wave, which travels along the fibers following excitation, is an indication of a reversible increase of permea-

bility. This has been shown to be true nowhere better than here, recently, by the studies of K. S. Cole and H. J. Curtis on the potential wave of *Nitella* and of the giant fiber of the squid, compared with the changes of resistance. It has frequently been suggested, especially in my own studies on the influence of inorganic salts upon the resting potential of muscles, that the artificial, local, reversible negativity which is brought about by ions is somewhat analogous to the negative wave sweeping along the fibers. Now, in recent studies in our laboratory, evidence has been obtained that under the influence of the same group of dispersing agents, which is effective in promoting secretory activity and which, likewise, activates the unfertilized eggs, there also takes place a reversible depolarization of the muscle and nerve membrane, as shown in Table V, where this might be interpreted by the assumption that the breakdown or the structural disorientation in the surface membrane, which is believed by many authors to arise during excitation, is brought about by an organic product of the more or less labile membrane components.

In concluding, I wish to point out the following:

1. Active transport of dissolved substances against concentration gradients is significant because in general, it takes place with substances unable to enter cells by mere diffusion. Acid dye-stuffs appear to be particularly apt to demonstrate this transport, because, unlike the frequently used so-called vital stains, which are basic in character and which enter all kinds of cells, they are allowed to pass only special cells, e.g., kidney epithelia. But this does not happen unless there are effective selective activities between the cell surface and the dyestuff. This is shown in experiments on the isolated Ringer perfused kidney. It appears

TABLE V
"Injury" Potentials Produced on Muscles

<i>Cations</i>	Molar.	Effect	<i>Anions</i>	Molar.	Effect
Diethylamine	0.05	+	Acetate	0.025	—
Dipropylamine	0.05	+	Butyrate	0.025	+
Dibutylamine	0.01	+	Valerate	0.02	+
Diamylamine	0.002	+	Caprylate	0.025	+
Dicaprylamine	0.0001	+	Nonylate	0.0005	+
			Oléate	0.0005	+
Veratrin	0.0001	+			
Novocain	0.0025	+	Benzoate	0.012	+
Codein	0.005	+	Salicylate	0.0008	+
			Glycocholate	0.002	+
<i>Nonelectrolytes</i>			Taurocholate	0.003	+
Heptyl alcohol	satur.	+			
Amylurethane	0.02	+	Toluensulphonate	0.05	—
Saponin	0.002 p.c.	+	Lactate	0.02	—
Digitonin	0.00001	+	Pyruvate	0.02	—
			Glycolate	0.02	—
Laurylsulphate	0.0003	+	Succinate	0.02	—
Cetylsulphate	0.001	+			
Hexylresorcinol	0.00001	+			
Sulphanilamide	0.012	+			

that a polar-nonpolar configuration of the dyes particularly favors the secretory transport. In other words, such dyestuffs which are built up by a nonpolar organophilic half and a polar hydrophilic half are fixed in the cell surface like in a Langmuir film. This anchorage on the cell surface is believed to be the first step in the secretory process.

2. With dyestuffs lacking such a polar configuration, other physico-chemical factors may come into play in the first uptake. This follows from the observations that triphenylmethanes likewise undergo secretion but only as long as the kidney is not washed out with Ringer's. This reminds one of the hypodynamic state of the frog's heart which appears after a Ringer perfusion of long duration.

3. The active transport of dyestuffs by the isolated Ringer perfused liver exceeds that of the kidney qualitatively as well as quantitatively. This means, first, that the concentration power of the liver exceeds by far that of the kidney; secondly, that Ringer perfusion does not abolish the secretion of triphenylmethanes.

4. Adsorbability of the dyestuffs appears to be an important conditioning factor in their strong excretion. This follows from the fact that attaching a great number of hydrophilic sulfonate groups prevents secretory uptake and that surface inactive substances like carbohydrates and inorganic ions pass the liver without change in concentration.

5. The dyestuff concentration power of the liver can be reversibly increased or decreased by the addition to the perfusion solution of certain organic compounds. Inhibitory compounds are surface inactive, anti-dispersing and condensing, promoting compounds are surface active, loosening and disintegrating, finally cytolizing. Inhibitory and promoting compounds balance each other.

6. Those substances which show a promoting secretory effect, are likewise effective in that they bring about a reversible depolarization in the resting muscle and nerve.

(This article is based upon a lecture given at the Marine Biological Laboratory on July 14.)

DIFFERENTIATION OF ISOLATED RUDIMENTS OF THE AMBLYSTOMA PUNCTATUM EMBRYO

DR. FLOYD MOSER

Rockefeller Foundation Research Fellow, Osborn Zoological Laboratory, Yale University

That rudimentary structures, such as the limb rudiment, transplanted between members of the same species or different amphibian species, develop much as they would have, had they not been removed from the parent animals, was long ago demonstrated by Born¹, Harrison², and by many others since then. The capacity for self-differentiation of many of the parts of relatively young and later stages of the amphibian embryo was thus tested.

Much less has been done, however, to test the capacity for differentiation of rudimentary structures by means of the explantation or isolation of parts. We are, of course, aware of Holtfreter's³ excellent studies on isolated parts of the amphibian germ, as well as of work, such as that of Fell and Canti⁴ on explanted limb buds of the 4-day chick, and work like that of Dorris⁵ on the explanted eye of the chick.

The experiments to be here reported were made during the winter and spring of this year. The technique, which has been developed in Harrison's laboratory, approaches asepsis. The manipulations were made by means of hair-loops and iridectomy scissors. The operations were made in ordinary Syracuse dishes in full strength Holtfreter's solution. After operation the explants and unoperated control animals were transferred to other Syracuse dishes where they were covered with approximately 8 cc. of Holtfreter's solution. Here the development of the explants was followed apart from the influence of host embryos.

The isolations, more than 1900 in all, were made from embryos of *Amblystoma punctatum*. Most of these were from Harrison's stage 29, though in some few cases, stages 27, 28 and 30 were also used. The explantations included those of the eye and its parts, the olfactory placode, the auditory placode, balancer rudiment, limb rudiment, gill rudiment and tail bud. As yet no sections have been made, hence for the present, the eye, and auditory and olfactory placodes must be omitted, since these must be sectioned for analysis.

Immediately after explantation, the cut edges of the isolated part approach each other and finally fuse in a common center. During this process of 'closure', as well as later, the explants move about in the culture dishes as a consequence of the activity of their ciliated epidermal coverings. This movement is mostly of a rotatory type.

In the majority of instances, the explant, be it that of the tail bud, the rudiment of the limb, gill or balancer, shows approximately the same degree and rate of differentiation as the intact rudiment in unoperated control animals. This observation holds only for the 10 or 11 stages immediately following operation. Thus, if the gill rudiment is explanted at stage 29, when there is no external indication of the gill as a morphological entity, then as morphogenesis of the gill occurs in the unoperated control animals, similar and practically equivalent differentiation occurs in the isolated rudiment. This is of some interest not only because of the degree of morphogenesis of the part in the complete absence of any influence of a host embryo, but also because of the fact that this differentiation is attained without nervous and vascular connections, while in the unoperated control material the nervous and vascular supply are well established. When in the unoperated animals stage 40 to 42 has been attained, then differentiation of the explanted rudiment comes to a standstill, or, if it continues, does so at a much slower rate.

The experiments with the gill rudiment are less striking, when instead of isolating the ectoderm, mesectoderm, mesoderm and entoderm, the ectoderm and underlying mesodermal layers alone are together isolated as a single explant. With these explants there seems to be a delay both in rate and degree of differentiation. Moreover, with few exceptions, only a single gill develops, while in the former case, consisting of all four layers, there are typically three gills as in the controls. Isolation of the ectodermal covering of the gill rudiment yielded nothing that was gill-like in appearance.

Explanted balancer rudiment consisting of ectoderm and the underlying layers of mesoderm and entoderm gave rise to what appeared to be perfect balancers, but these were no better than those obtained from isolated balancer ectoderm alone. Here, too, there is a well established nervous and vascular supply in the balancer of the unoperated controls, while in the experimental balancers these connections are absent.

¹ Born, G. (1894) Jahresber. d. Schles. Ges. f. vaterlandische Cultur. Medicinische Section. 11 pp.

² Harrison, R. G. (1898) Roux' Archiv., 7, 430.

³ Holtfreter, J. (1938) Roux' Archiv., 138, 522.

⁴ Holtfreter, J. (1938) Roux' Archiv., 138, 657.

⁵ Fell, H. B. and R. G. Canti (1934) Proc. Roy. Soc., Lond. B, 116, 316.

⁶ Dorris, F. (1938) J. E. Z., 78, 385.

In all cases, the isolation of the limb rudiment consisted of the mesoderm and its overlying sheet of ectoderm. These explants differentiated along with control material as far as stage 41 to 42, and then abruptly slowed down in rate, though in many instances continued at a lower level until two well marked digits as well as the beginning of a third digit were present. Characteristic surface contours make it possible to tell whether a rudiment has come from the right or the left side of the embryo, even before there is any evidence of the development of digits.

Tail-buds, too, keep pace both in rate and degree of differentiation until unoperated controls have attained stage 40 to 42. When control animals reach stage 38 to 39 and actively move about in their containers, the isolated tails exhibit function in the sense that they twitch when stimulated by means of slight pressure with a hair-loop. This was, perhaps, to be expected, since myotomes and muscle cells are perfectly evident in these ex-

plants. Moreover, the explants doubtless also included the posterior end of the nerve cord. That nervous tissue is present is indicated by the fact that tactile stimulation at one portion of the tail explant in many instances caused a response to occur some distance removed from the site of stimulation. The presence of melanophores and lipophores in the explants supplies additional evidence in this direction, since they arise from neural crest cells and since it does not seem probable that the crest could have been separated from the nerve cord in making the isolations of the tail-bud.

Perhaps more interesting than the experiments here reported are those involving the quartering, halving and doubling of rudiments at the time of isolation, and others in which isolated rudiments of various ages have been grafted back to host embryos. These as well as the present experiments will be reported at greater length elsewhere.

(This article is based upon a seminar report given at the Marine Biological Laboratory on July 11.)

PRODUCTION OF DUPLICITAS CRUCIATA AND MULTIPLE HEADS BY REGENERATION IN PLANARIA

MR. ROBERT H. SILBER

Fellow in Zoology at Washington University

It's an old story that planaria possess remarkable regenerative abilities. Practically everyone who has taken a course in zoology has demonstrated to his own satisfaction that a head regenerates at an anterior cut surface and a tail at a posterior cut surface. This is in accordance with Child's theory of axial gradients that the most anterior portions of a planarian have the highest physiological activity and that a head always regenerates at the point of highest activity.

However a number of investigators have succeeded in producing bipolar forms, with two heads in opposite directions. Obviously the polarity of a planarian is not necessarily fixed since it can be altered by simple operation.

Morgan and others have produced bipolar forms from short transverse pieces. As early as 1896 van Duyne produced a peculiar type of bipolar planarian by merely splitting the animal to the head region. In a few favorable cases the tails remained separated and a new head developed in the crotch just posterior to the original head and in the opposite direction.

My experiment one is based on a modification of this operation which was first used by Beissenhirtz in 1928.

Planaria (100) were split in the median line to a point half way between the auricles and the anterior tip of the pharynx (which was removed). After one day the head portion was removed by a transverse cut leaving two "half-tails" held together at their anterior ends by a narrow strip of

tissue. These two "half-tails" assumed a "horse-shoe" shape shortly after the operation and of course this configuration kept the two half-tails from healing back together.

In a majority of cases two head outgrowths appeared on the third day perpendicular to the cut surfaces, and after eight days two well developed heads were present directly opposite each other—a duplicitas cruciata type of animal. After several weeks it is impossible to determine the original anterior and posterior ends of an animal of this type except by the position of the pharynxes in the two tails. The pharynxes always developed near the longitudinal cut surface, in the new tissue.

This development of two heads in opposite directions might be expected on the basis of the gradient theory since the anterior head should normally regenerate and the crotch head is located at the most anterior point along the longitudinal cut surface.

However 9 of the 100 animals in this experiment did not develop anterior heads. This was correlated with the amount of wound tissue present after the healing process. Nine other cases in which very little wound tissue was exposed anteriorly after healing developed abnormal heads. The remaining 82 animals had sufficient wound tissue available for the development of normal heads.

(Continued on page 68)

The Collecting Net

A weekly publication devoted to the scientific work at marine biological laboratories.

Edited by Ware Cattell with the assistance of Boris I. Gorokhoff and Mona Garman.

Entered as second-class matter, July 11, 1935, at the U. S. Post Office at Woods Hole, Massachusetts, under the Act of March 3, 1879, and re-entered, July 23, 1938.

Introducing

DR. PIERRE DUSTIN, JR., Assistant in the Department of Pathology at the University Hospital of Brussels; Graduate Fellow of the Belgian-American Foundation at Harvard University.

Dr. Dustin has followed in the footsteps of his father, who is a Professor of Pathology at the University of Brussels. Born and educated in Brussels, the younger Dustin received his degree of Doctor of Medicine there in 1937.

Dr. Dustin's interest has lain in the field of hematology. While preparing for his doctor's degree, he conducted research work on the spleen; this work brought him the award of a Belgian government fellowship. Immediately after he had received his doctor's degree, he spent a month at the marine biological laboratory in Roscoff, France, where he studied the spleen of fishes. He continued this research at Paris, where he also worked in clinical hematology.

In 1938 he studied the histology of the human spleen in the Department of Pathology at the University of Zürich under the direction of Dr. von Meyenburg.

Dr. Dustin arrived in America in September, 1938, and worked at the Thorndike Memorial Laboratory at the Boston City Hospital under Dr. George R. Minot, and also in the Department of Pathology in the same hospital. He studied clinical cases and conducted research on the relation between fat in the spleen of birds and nutrition. He remained there until last May.

At the Marine Biological Laboratory this summer Dr. Dustin is completing and systematizing the work that he has done in America. In addition to studying slides which he made at the Boston City Hospital, he is doing bibliographical work at the Laboratory library.

After he completes his work in Woods Hole, Dr. Dustin is planning to attend the International Cancer Congress, which will be held in Atlantic City in September and at which his father will participate as a Vice-President. He will later return to Belgium, where he expects to resume his work at the Brussels Hospital.

NEURAL DIFFERENTIATION WITHOUT ORGANIZER

(Continued from page 53)

ferentiates from the anterior end of the explant since when two explants are united by their anterior ends a neural tube appears in the middle. Further, when an anterior half explant is fused with the anterior end of a whole explant the neural tube forms at the end. Other fusions also show that the anterior end forms the neural tube. There is then an antero-posterior polarity or gradient in the isolated ectoderm and this polarity must be maintained in order to obtain neural tubes without organizer.

The antero-posterior gradient exhibits itself further by differences in oxygen consumption. The roof of the blastocoel was cut into four parts along the anterior posterior axis from the dorsal lip to the ventral epidermis. The results show that the oxygen consumption is high in the anterior pieces of ectoderm and low in posterior pieces. The dorsal lip respire at about the same rate as the anterior end of the ectoderm.

(This article is based upon a seminar report given at the Marine Biological Laboratory on July 11.)

DR. AND MRS. CHARLES PACKARD will be at home to members of the Laboratory Sunday afternoons July 23 and 30 from 4:30 to 6:00 o'clock.

Work in the physiology course of the Marine Biological Laboratory ends to-day, and the other three classes complete their sessions during the coming week. The embryology course ends on Wednesday, the 26th, and the botany course on the 29th. The protozoology course continues through July 31. The invertebrate zoology course will open on the 29th; it will close on September 7th.

CURRENTS IN THE HOLE

At the following hours (Daylight Saving Time) the current in the Hole turns to run from Buzzards Bay to Vineyard Sound:

Date	A. M.	P. M.
July 22	9:21	9:51
July 23	10:17	10:51
July 24	11:14	11:59
July 25	..	12:15
July 26	1:01	1:14
July 27	2:03	2:07
July 28	2:56	3:04

In each case the current changes approximately six hours later and runs from the Sound to the Bay.

ITEMS OF INTEREST

The *Atlantis* sailed on July 20 to take bottom cores of submarine canyons on Georges Bank under the direction of Mr. H. C. Stetson. It returned on Sunday, July 16, after the accident in which George Priest, a crew member of the *Atlantis*, was killed together with two Coast Guardsmen, as a plane was taking him from the ship in mid-ocean for medical treatment.

PROFESSOR ULRIC DAHLGREN, professor of biology at Princeton University, retired last month. He had been teaching at Princeton since 1895, becoming full professor in 1911.

DR. GERHARD FANKHAUSER, assistant professor of biology at Princeton University, has been promoted to an associate professorship.

DR. DAVID R. GODDARD, who is on the staff of the botany course at M.B.L., has been promoted from instructor to assistant professor of botany at the University of Rochester.

DR. WILLIAM O. PUCKETT, instructor in biology at Princeton University, has been promoted to assistant professor.

DR. J. A. MOORE, who has been an assistant in zoology at Columbia University, has accepted a position as tutor in biology at Brooklyn College. He will teach a course in experimental zoology.

DR. LAUREN GILMAN, who received his doctor's degree at Johns Hopkins University this spring, has been appointed assistant in zoology at that institution. His thesis was on mating types in diverse races of *Paramecium caudatum*.

DR. RUSSELL CARPENTER, professor of zoology at Tufts College, was in town for the day on July 18. He was accompanied by Mr. Herman Sweet, instructor in biology at Tufts, and Mrs. Sweet.

PROFESSOR WILLIAM F. ADDISON, professor of anatomy at the University of Pennsylvania, has returned to Philadelphia in order to complete his book on the histology of the rat. He will return to Woods Hole soon.

DR. H. B. GOODRICH, director of the embryology course at the Marine Biological Laboratory, left on July 10 for the Bermuda Biological Station, where he will conduct research on tropical fish for a few weeks.

MISS LENA LEWIS, research assistant in physiology at Ohio State University and an investigator at the Marine Biological Laboratory last summer, was severely injured in an automobile accident last April while on the way to attend the Toronto meeting of the American Physiological Society. She is recovering from the accident.

DR. T. H. BISSETTE, director of the invertebrate course at the M. B. L., visited the Marine Zoological Laboratory at the Isles of Shoals on July 12 where he gave the Wednesday evening lecture reviewing his work on photoperiodicity. Dr. F. R. Kille accompanied him and lectured before the class the next morning on regeneration in holothurians. On Thursday afternoon they made field trips to tide pool areas in the vicinity.

DR. GEORGE W. KEIL, a physician in Columbus, Ohio, has been visiting his sister, Dr. Elsa M. Keil, this week.

The following companies have held or are holding exhibits at the Marine Biological Laboratory: American Instrument Company represented by S. B. Young; P. Blakiston's and Son by R. Bowman; General Biological Supply by A. S. Windsor; E. Leitz by Charles A. Brinkman; MacMillan Company by J. H. Behnke; W. B. Saunders Company by E. R. Ziber; Spencer Lens Company by C. P. Riley and E. F. Munoz.

MR. COLUMBUS O'D. ISELIN presented a paper at the weekly seminar on Thursday at the Woods Hole Oceanographic Institution on "Some Preliminary Results of our Gulf Stream Program."

The following papers have been presented at botany seminars: *July 13*: "The Relation between Cell Size and Organ Size in Cucurbit Fruits," by Professor E. W. Sinnott; "Wound Healing in Higher Plants," by Dr. R. Bloch. *July 20*: "The Reversible Activation of Respiration in the Ascospores of *Neurospora tetrasperma*," by Dr. D. R. Goddard; "Fertilization, Ooblastema Development and Cystocarp Formation in *Agardhiella tenera*," by Dr. B. F. D. Runk.

M. B. L. CLUB

The following officers were elected at the annual meeting of the M.B.L. Club last Monday evening: Dr. William Duryee was elected President to succeed Professor H. B. Goodrich; Dr. W. W. Ballard, for several years Secretary-Treasurer, was made Vice-President; and Dr. P. S. Crowell, Jr., Secretary-Treasurer. It was decided at the meeting to obtain some more chairs for the Monday evening concerts. Chairmen of various committees presented reports; Dr. S. E. Hill described damage by the hurricane to the building, which was partly undermined and which still needs jacking although the foundation was replaced. Mrs. M. W. Bosworth, Chairman of the House Committee, made a plea for further donations to the Club library; she also reported that 260 persons had joined the Club, an increase of about 70 over the membership at the corresponding time last year.

DEPARTMENT OF PUBLICATIONS

AN INTRODUCTION TO GENETICS, by A. H. Sturtevant and G. W. Beadle. 391 pp. W. B. Saunders (Philadelphia). 1939. \$3.25 net.

This is a new textbook designed for use in an elementary course in genetics. It is also a most welcome contribution from a laboratory which has for so many years been an outstanding center of genetic research. More than any other text now available it presents genetics as a logical science based on numerical and cytological observations and upon simple deductions. Accordingly, the usual historical approach has been largely abandoned in favor of a rational and more natural presentation of the facts of genetics. The book begins with the simplest of ratios—the sex ratio. After a brief discussion of simplified probability (amplified in an appendix) and of the inheritance of sex-linked characters, it proceeds to autosomal inheritance, independent assortment, linkage, intra-chromosomal rearrangements, and the many and more complex phenomena of modern genetics. The results of the latest investigations in the fields of cytogenetics, race hybridization, and population studies, in both animal and plant forms, are perhaps of particular interest.

The style of the writers is succinct and lucid. Their treatment, in general, however, will seem to many to be too brief and with too little elaboration of the points discussed. This, however, can work to the advantage of the teacher, who is thus given ample opportunity for detailed discussion and illustration in his lectures. If this be done properly, students will certainly find the book and its many new diagrams an excellent presentation and review of the essential facts. The references at the ends of the chapters are carefully and well chosen to amplify whatever points the reader finds of particular interest or difficulty. The comprehensive problems at the close of each chapter,

while sometimes too difficult for the average elementary student of genetics, will certainly test the student's grasp of the principles which have been discussed.

The material used for illustrations of points is largely from maize and *Drosophila*. But where other forms offer as good or better examples they are also discussed. The use of maize and *Drosophila* examples serves the more to make the elementary course a laboratory one.

The book deals with facts which seem to the authors to be reasonably well established. Discussions of observations the interpretations of which are still controversial are accordingly either omitted or stated as simply and fairly as possible, even though by so doing many problems of particular interest to one group or another are either passed over entirely, or inadequately discussed.

Whenever possible (and in genetics this is often) the discussion is presented in diagrams as well as words. In the several chapters dealing with crossing over and chromosome aberrations this visual education is particularly well done.

The book should be a success with students having a well established interest in genetics. It will be interesting to see if this rather new type of treatment will be as successful with the usual course in liberal arts colleges. Its popularity in this latter type of course would be increased by the addition of a section devoted to human genetics; but whether its value as a scientific textbook would be similarly increased is debatable. The authors have included examples from studies in human heredity (the blood groups especially) only so far as they are clear illustrations of points under discussion. They have steered clear of all eugenic and sociological implications.

DR. PHILIP IVES,
Amherst College

PHYSIOLOGY CLASS NOTES

The other day a large parcel arrived for one of our esteemed associates. Prominently printed at the lower left corner the sender, facetiously, had given the postal authorities additional instructions to the effect that the box was to be delivered only to the Newlyweds. A nice state of affairs. A bride and groom with us and we not aware of it. Previous to this we had been a little suspicious of C.,—now, the reaction was catalyzed and the past reconstructed itself. When he left to attend a wedding at the end of the first week of the course—it was his own wedding. Congratulations and much happiness!

With the formal part of the course concluded, each of us has undertaken a small problem for the

remaining week or ten days. On Saturday and Monday everyone was on business bent, setting up apparatus, preparing solutions and almost forgetting about meals. By Tuesday evening, however, there were some not quite so sure that they had the scientific world "by the tail," and the publishing of their "brain-children," if any, may not now take place until after the equinoxes next year.

We are much impressed with the M. B. L. and Woods Hole, and we shall leave with sadness when the time comes. The new associations have been thoroughly pleasant and the kindly interest of the staff has been much appreciated.

—R. H. Heming

EMBRYOLOGY CLASS NOTES

"Motility" has taken on a new and sinister meaning for the embryologists whose patience and nerves have been strained far past the proverbial breaking point by the elusive annelid trochophores as they, the trochophores, swam around, over, under, and through the lens paper mesh intended to ensnare them. The pursuit of a sabellaria even led one eager scientist to lie in wait until 3:30 A. M. until the wary annelid finally was sighted, but sadly enough, the embryologist was so bleary-eyed by then that he couldn't see straight enough to draw it! Having put the ciliated and bewhiskered annelid trochophores into more or less accurate diagrams, the class is reported to be gaining in the race with the mollusc larvae under the capable guidance of Dr. Hamburger.

Earlier in the week Dr. Costello led the class through the maze of spiral cleavage as displayed by crepidula. The whirring of the centrifuge was later replaced by the odors of alcohols as the class turned from the effects of centrifugation on cell lineage to the preparing of slides of various cleavage stages of crepidula.

Because one year the float back of the supply department sank when the whole embryology class got out on it to study the breeding habits of nereis, the class was divided and assembled on two different evenings. Armed with electric lights, collecting nets, and finger bowls, the embryologists perched perilously on the edges of the wooden structure. There were some tense moments when two of the long-legged students hung suspended from a drifting boat and the float, but the ma-

rine forms were spared the shock of having such relatively huge forms plunge into the water.

Dr. Mary E. Rawles precipitated some lively discussion by her excellent lecture on her experimental work on pigmentation in feathers by grafting ectoderms from a bird of one pigmentation to the embryo of another. Her slides and discussion of her results were much appreciated by the class.

Another lecture attended with much interest was that given by Dr. Roberts Rugh. In addition to his slides and movies on the ovulation of frogs, he reported some of his recent work with X-rays on sperm with the resultant effects on the embryos.

In less serious moments the embryologists give vent to their feelings by breaking forth in song accompanied by a guitar and violin in the court of the old lab building. Occasionally arbacia appear in peculiar places such as in shoes and on chairs!

Although the picnic is stale news to the rest of the world, its effects are still with us in the form of peeling epidermis. One worthy sufferer reports the amazement of the dormitory maid at the amount of epidermis piled on the floor of his room. Other true scientists subjected layers of shoulder and back to scrutiny under a microscope. Vital stains were quite ineffective!

May we offer our services as tutors to the Botanists so that in the future they will be able to recognize the evident differences between a very superior type of the genus *Homo* and the lowly crustacean?

—Frances Pauls

BOTANY CLASS NOTES

Two outstanding speakers were featured at last Thursday's seminar. Dr. Sinnott, professor of botany at Columbia University, started the program with an excellent summary of his work on the relation between cell size and ovary size in the growth of *Curcubita pepo*. Dr. Bloch, also of Columbia, made a most interesting comparison between wound healing in plants and animals.

The last trip was an all-day excursion to Penikese Island and Gay Head. After landing at Penikese, the class walked across the island, taking care not to step on the bird's eggs which are laid in bare spots on the hillsides. Because of our caution, it is to be hoped that no mother bird returned to her nest to find her offspring scrambled. Collecting along the shore was excellent, despite the battering one received from the waves, and a goodly number of species was lugged home. This was our first experience with *Fucus*-covered rocks, and as a result, some of the budding phycologists

found themselves unexpectedly in a sitting position.

The wind came up on the way to Penikese, and the good ship *Nereis* attempted to go three ways at once. The members of the class proved good sailors, however, and all lunches remained securely moored.

At Gay Head, there was a fine wash. Much *Rhodonemia* and *Polysiphonia* were dumped into the buckets, but, from an aesthetic standpoint at least, the delicate *Plumaria* was the prize catch of all.

As we approached Woods Hole, the sky grew blacker and blacker. Finally when we were within a few hundred yards of the dock, the storm broke, and the class cowered under the *Nereis'* semi-waterproof deck. Despite the storm, it was a very successful trip in every way.

The botany class reached its full quota with the arrival of Mrs. Thivy from Madras, India. Mrs. Thivy says that in her country algologists do not

work after supper. This idea has the hearty approval of our class because *huile de minuit* has been taking an awful beating lately.

An excellent relaxation from the allures of the *Phacophyceae* have been the Sunday afternoon rides with Mr. Nicholson, rector of the Church of the Messiah. By taking the class in groups,

Mr. Nicholson has shown us what Cape Cod and Cape Codders are really like.

The eminent Dr. Runk has started a fad of Corn Cob pipe smoking. Most of the male members have now succumbed to the charms of smoking a real pipe. The one attempted female conversion used her acquisition for blowing bubbles, carrying on true Wellesley tradition.—*Bob Page*

PRODUCTION OF DUPLICITAS CRUCIATA AND MULTIPLE HEADS BY REGENERATION IN PLANARIA

(Continued from page 63)

The most striking aspect of this experiment however was the appearance of posterior duplications and lateral heads in 17 cases, as follows:

7 cases with 1 posterior outgrowth and 3-4 eyes	
3 " " 2 " outgrowths " 3-4 "	
4 " " 2 " " " 5-9 "	
3 " " 3 " " " 5-6 "	

Duplications were never observed at the anterior surface.

These lateral heads are of particular interest because they are *not* located at the highest point along the longitudinal cut surface. That position is taken by the crotch head. Therefore they can not be explained on the basis of the gradient theory except by the assumption of local factors which "step up" the activity at certain points along the cut surface, thus emphasizing the medio-lateral gradient to the practical obliteration of the anteroposterior gradient, which is normally involved in head regeneration.

In this connection two cases obtained at Cold Spring Harbor in preliminary experiments were of interest. These were cases of the *duplicitas cruciata* type, the tails of which were split a second time, 8 days after the first operation, while the tails were still actively regenerating. The two "outer" half-tails which consisted of old tissue, developed numerous eyes in broad lateral head outgrowths and tore off within two weeks. The other two half-tails consisted almost entirely of regenerated tissue and showed no sign of developing heads.

Since this operation produced lateral head formation to such a high degree, 20 animals of the *duplicitas cruciata* type from experiment one were split in a similar manner, 8 days after the first operation.

The Cold Spring Harbor results were not exactly repeated but out of 31 heads which developed, 24 or 77% were lateral heads. Apparently in experiment two, conditions favored lateral head formation—in experiment one, crotch heads were favored. The essential difference between the two experiments was that in the second, the two tails

were in an active process of lateral regeneration when the cuts were made.

Since the lateral heads of experiment two always grew out in the same direction in which tail regeneration was taking place, it seems as though the presence of regenerating tissue "conditions" the old tissue for lateral head formation, whereas neither old tissue nor regenerating tissue alone shows this property to any extent.

That is, the operation separated the newly regenerated portion of the tail from the old tissue of the original animal, and the lateral heads always grew out from the old tissue, never from the new. Therefore the direction of outgrowth of lateral heads coincided with the direction of lateral regeneration of the tails—strongly indicating a correlation between the two processes.

This consideration led to a third experiment in which tails of *duplicitas cruciata* animals were allowed to almost complete their regeneration before being split the second time. The idea was that, if the tails were allowed to regenerate longer, they should more closely resemble the tails of an unoperated, normal animal.

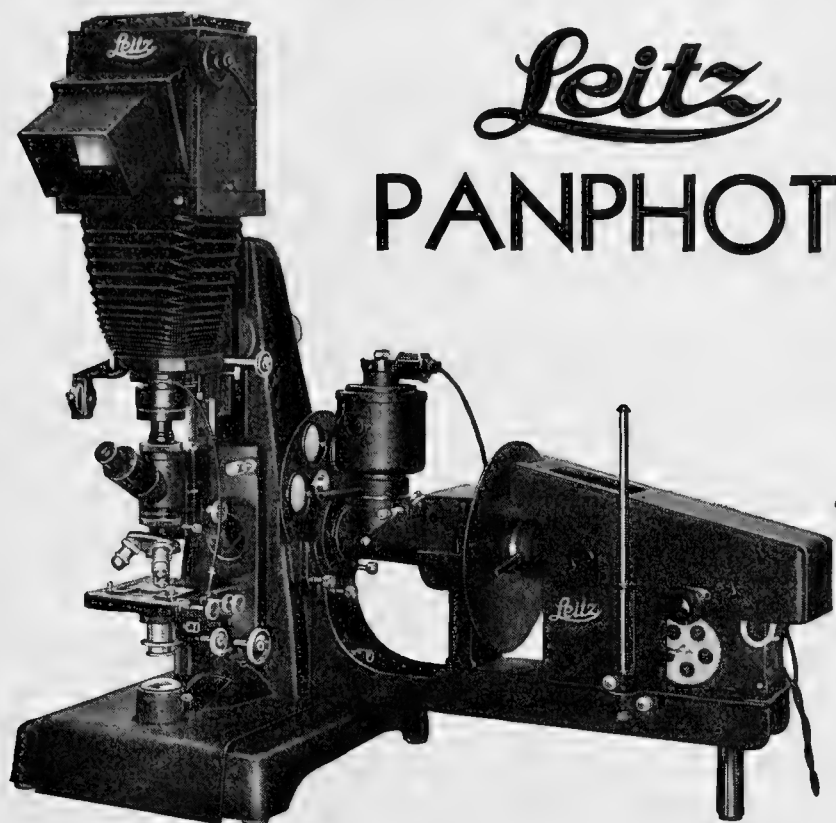
Therefore we should expect the formation of crotch heads to be favored again as in experiment one if the lateral regeneration of the tails was responsible for the predominance of lateral heads in experiment two.

As we had expected, crotch heads were definitely favored over lateral heads in these animals. 15 of the 20 heads which regenerated were now in the crotch—only 5 were lateral.

It is clear then that operation one on normal animals produced only 13% lateral heads; the resplitting of the regenerating tails in experiment two produced 77% lateral heads; and the same operation on almost fully regenerated animals produced only 25% lateral heads.

In all probability if the *duplicitas cruciata* animals were allowed to complete their regeneration before resplitting the tails, the percentage of lateral heads would closely approximate the percentage of lateral heads obtained by splitting normal animals as in experiment one.

(This article is based upon a seminar report given at the Marine Biological Laboratory on July 11.)



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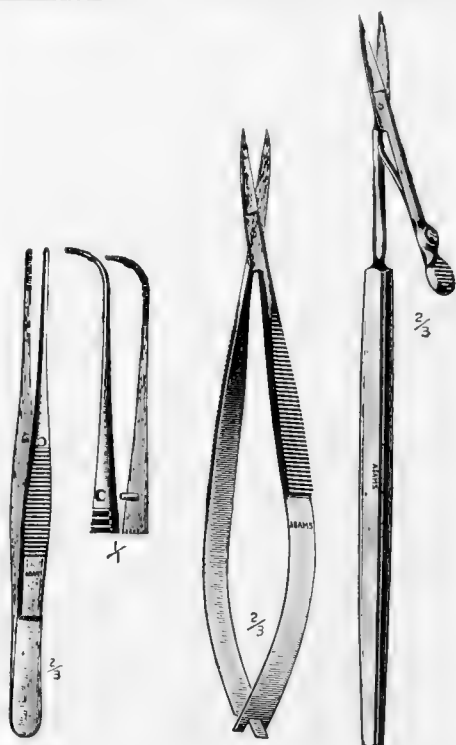
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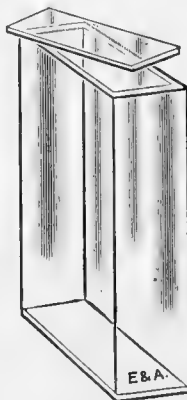


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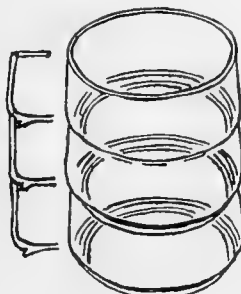
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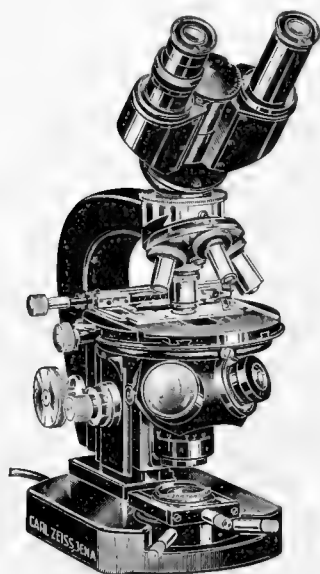
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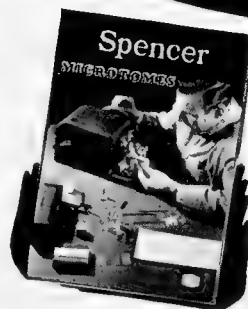
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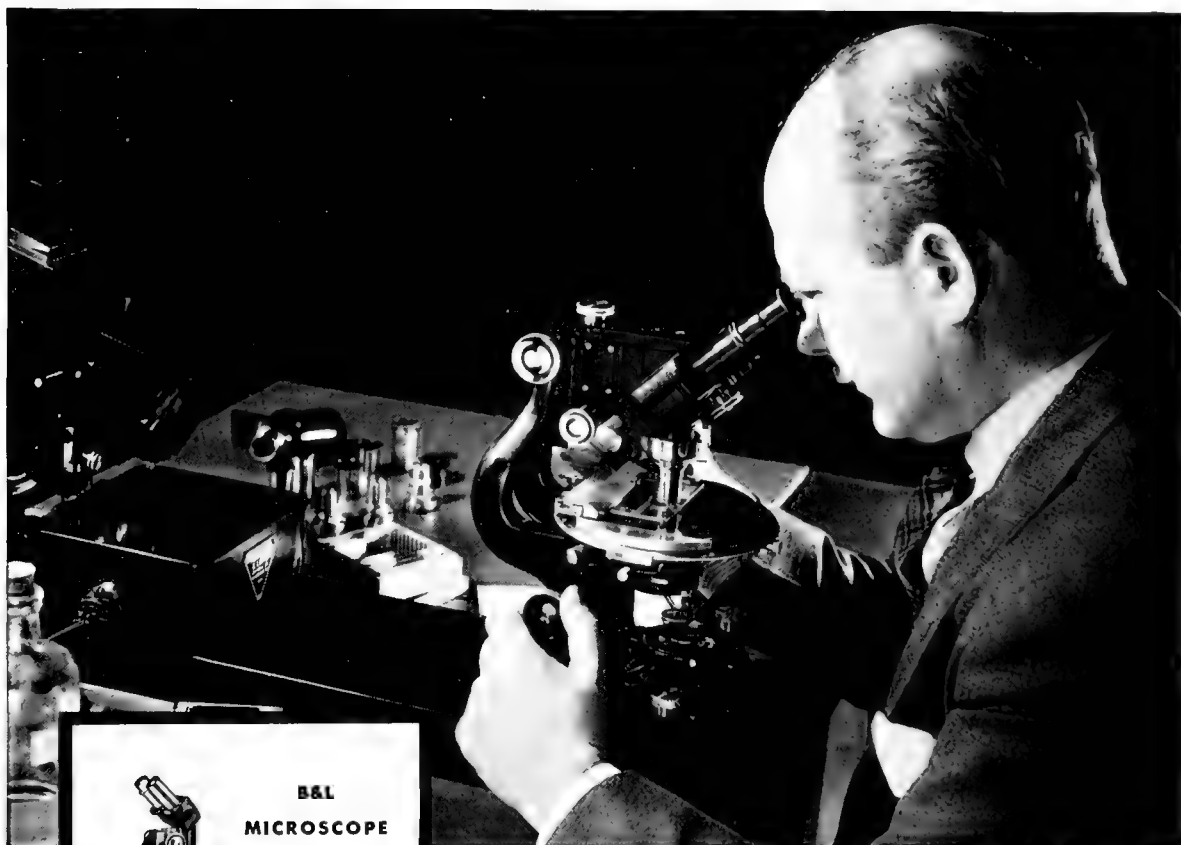
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*Professor of Biology,
Swarthmore College*

Air breathing vertebrates breathe air of constant composition which is still further regulated in constancy by the method of ventilating the alveoli of the lungs. In fresh water, on the other hand, fish encounter a variety of respiratory conditions, particularly in temperate climates. It is not surprising that the properties of the blood of fish which are concerned with the transport of oxygen vary from species to species while those properties differ little in the blood of different species of mammals.

In representing the ease of combination of oxygen with the blood of seven fresh water fish, a family of similar curves appears which differ only quantitatively in ease of combination with oxygen. Knowing the type of curves, the P_{O_2} necessary for half saturation of each kind of blood serves to define the whole curve, and the combination of oxygen with the blood of each species can be indicated by the figure (Continued on page 84)

SEXUALITY AND RELATED PROBLEMS IN PARAMECIUM

DR. TRACY M. SONNEBORN

*Associate Professor of Zoology,
Indiana University*

Two distinct problems of sexuality appear in the conjugation of *Paramecium*: (1) Are the uniting conjugant individuals sexually different?

(2) Are the uniting gamete nuclei sexually different? On the one hand it has been held that here is a sex act without sex differences of any kind; on the other, that sex differences characterize either the gamete nuclei or the conjugants or both. Attempts have even been made to identify the rudiments of male and female.

I shall examine in detail the question of sexual differentiation between the individuals that unite in conjugation. Morphological differences between the two members of a conjugant pair do not occur regularly, though they are sometimes observed. But Jennings and others showed mates to be more commonly alike in

these respects than expected by mere chance. Mating is assortative: like tends to mate with like.

M. B. L. Calendar

TUESDAY, August 1, 8:00 P. M.

Seminar: Dr. Leonard I. Katzin: "The Ionic Permeability of Frog Skin as Determined with the Aid of Radioactive Indicators."

Dr. Kenneth Bailey: "Muscle Proteins."

Dr. Theodor von Brand: "Chemical and Histochemical Observations on *Macracanthorhynchus hirudinaceus*."

Mr. C. L. Claff and Dr. G. W. Kidder: "pH Reactions During Feeding in the Ciliate *Bresslana*."

FRIDAY, August 4, 8:00 P. M.

Lecture: Dr. G. K. Noble: "Neural Basis of Social Behavior in Vertebrates."

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AIRPLANE VIEW OF WOODS HOLE

with Juniper Point, the Buoy Yard, and Little Harbor in the immediate foreground. The biological laboratories are in the center of the upper right-hand quarter of the picture.

Regular physiological differences likewise appeared to be lacking, though Maupas made 50 years ago an observation suggesting otherwise. He failed to obtain conjugation among animals from a single natural source; cultures conjugated only when they contained animals from more than one natural source. Maupas concluded that diversity of ancestry was a necessary condition for conjugation. This implied physiological difference between conjugants was discredited when a number of investigators found conjugation abundantly among the progeny of a single individual. Apparently any two paramecia of the same species could conjugate with each other if they were capable of conjugating at all. In this sense *Paramecium* exemplified sexless mating.

But knowledge of these matters has radically changed in the last two years. In describing this newer knowledge of mating I shall present first the usual, typical relations, reserving for later certain instructive exceptions.

In *P. aurelia* individuals containing macronuclei descended from one original macronucleus do not conjugate with each other. Such a group of individuals is called a caryonide. Caryonides terminate and new ones are formed when the macronuclei are destroyed and replaced by products of the micronucleus during the reorganization following conjugation and during endomixis or autogamy. At such times usually two new macronuclei arise in each reorganizing individual and these go into different cells at the first fission. The fact that individuals of the same caryonide do not conjugate with each other agrees with Maupas' observation that closely related individuals do not interbreed. But if several caryonides are present in the same culture, even though all come from a single original individual, they may conjugate. This agrees with the observation of the opponents of Maupas who found conjugation within a clone.

The explanation of these facts appears when several caryonides are cultivated in different dishes and samples of each are mixed with samples of each of the others. In some of the combinations nothing happens: the animals pay no attention to each other; each individual goes on its own way in splendid isolation. But in other mixtures the animals quickly unite in large clusters. In the course of an hour or so these clusters break down into conjugating pairs. In the mating reaction, animals stick together as they collide in their random movements. Animals not in contact do not attract each other. Nor are

they in a specially sticky condition, as has been so often maintained, for neither caryonide shows the least trace of stickiness until they are mixed and then only when animals of different caryonides collide. The clusters begin with just two individuals and build up into larger aggregations by the repeated addition of other individuals as they collide with those already united.

The final conjugating pairs always consist of one individual from each of the two caryonides. When the two caryonides differ in size, each pair consists of one large and one small animal. In *P. bursaria* the two members of each pair differ in color when a normal green culture is mixed with one made white by being grown in the dark.

What determines whether two caryonides will or will not react in this way when mixed together? The answer appears when all possible combinations are made among a group of caryonides. The caryonides are classifiable on the basis of their reactions, into two groups: no two members of the same group will conjugate with each other, but any two caryonides from different groups will. These two groups are said to be of different mating types, and may be arbitrarily designated as I and II. Conjugation occurs between types I and II, never between individuals of the same type, whether they be members of the same or different caryonides. Standard cultures of the two types are maintained permanently in order to be able to ascertain the type of any unknown caryonide. This is done by mixing some of its animals with type I and some with type II; conjugation occurs in one of the mixtures, not in the other. The type of the new caryonide must then be the same as the type with which it did not conjugate, the opposite of the one with which it did. For example, if a culture fails to conjugate with type I, but does with type II, it is type I.

Nearly fifty stocks of *P. aurelia* collected from various regions between Canada and Florida and from coast to coast have now been analysed. Nearly all show a similar system: in each stock all caryonides are classifiable into one or the other of two mating types. The few remaining stocks consist exclusively of but one mating type. Thus all caryonides of stock B conjugate with type II from another stock, none with type I; so stock B consists exclusively of type I. Studied alone, stock B would be considered non-conjugating because it never conjugates among its own members. All so-called non-conjugating stocks behave

like this; they consist of only one mating type and conjugate readily when mixed with the proper type from another stock. Mating types appear to be of universal occurrence in *P. aurelia*.

Although not more than two mating types occur in any one stock, more than two must exist in the species, for both mating types in some stocks fail to conjugate with either of the types in certain other stocks. Altogether six different mating types have been found. One group of stocks (B, F, J, etc.) contains types I and II; a second group (A, C, D, etc.) contains types III and IV; a third group (M, Q and Y), types V and VI. Conjugation takes place only between the two types in the same group, never between types in different groups. This sexual isolation of the three groups of stocks makes them distinct genetical species; but they appear to be morphologically alike, all conforming to the description of the taxonomic species *P. aurelia*. However, they are physiologically diverse in a number of ways.

Each mating type is uniquely defined by the type with which it mates. The mating type of a culture can be ascertained by mixing some of its animals with standard cultures of each of the six mating types. With one and only one of these it will conjugate. Its mating type is the other one in the group with which it mates. For example, if it mates with type V, it belongs to group 3 and is of mating type VI.

In *P. bursaria* Jennings reports somewhat different mating type relations. Each stock of this species shows only one mating type. As nuclear reorganization is extremely rare, a stock is practically equivalent to a caryonide of *P. aurelia*. The mating types fall into three different groups or genetical species, with no conjugation between types in different groups. In group I occur the four mating types A to D; in group II, the eight types E to M; in group III, the four types N to Q. In each group each mating type conjugates with all the other types in that group. This system of multiple interbreeding types is in marked contrast to the system of paired types in *P. aurelia*. To discover the group to which a new stock belongs, it must be mixed with at least two types from each of the three groups. It will conjugate with one or both of the types from one group, not with any of the others. It belongs to the group with which it conjugates. To discover its mating type it must now be mixed with all the types of this group until one is found with which it will not conjugate. It is then of the same type as this one. For example, if it mates with A, B and C, but not with D, it is of mating type D.

Six of the seven species of *Paramecium* found in this country have been examined for mating types and all have shown them. *P. aurelia* and *P.*

bursaria have already been discussed. In *P. caudatum* Gilman finds the same kind of system I found in *P. aurelia*: six mating types occurring in three groups, with only two interbreeding mating types in each group and no conjugation between types in different groups. In *P. calkinsi* I have found two mating types and in *P. trichium* three interbreeding types indicating a system of multiple types such as Jennings found in *P. bursaria*. Giese has found two mating types in *P. multimicronucleatum* and Woodruff has found two in *P. woodruffi*.

Kimball found in *Euplotes*, a representative of a different order of ciliates, a system of mating types like the one in *P. bursaria*. There are five groups of non-interbreeding types with morphological differences between some of the groups indicating that these may be taxonomically as well as genetically different species. In each group occur multiple interbreeding mating types, six in the group most fully studied, and any one of these conjugating with any of the other five. The striking agglutinative mating reaction so characteristic of *Paramecium* appears to be lacking: conjugation occurs first several hours after mixture of the different types and then pairs form directly without the prior formation of clusters.

In view of present knowledge it seems allowable to include Maupas' old evidence for the necessity of diverse ancestry as evidence for diversity of mating type. If so, at least four more species must be added to the list of those in which mating types are known: *Stylonychia pustulata*, *Leucophrys patula*, *Onychodromus grandis* and *Loxophyllum fasciola*.

This brings the number of species now known to have mating types to about a dozen. These belong to six different genera and two different orders of ciliate Protozoa. It appears therefore that mating types will be found to be widely distributed and possibly universal among the ciliates. The view that any two individuals of the same species can conjugate with each other if capable of conjugating at all—until two years ago generally accepted—is now demonstrably false; on the contrary, in general conjugation can take place only between individuals of diverse mating types.

Are there ever exceptions to this general rule? Does conjugation ever take place between animals of the same mating type? In nearly all the species examined in detail conjugation has been observed in cultures containing only one caryonide, and as members of the same caryonide are presumably of the same mating type, this appears to be conjugation between animals of the same mating type. Can individuals of the same caryonide ever differ in mating type? And is this the explanation of these exceptional conjugations within a caryonide?

There is only one method of answering these questions directly. The two animals that come together for conjugation must be separated before they become too tightly united and the mating types of the two members of such a split pair must be directly ascertained by placing each of them separately in standard cultures of the different types to discover with which ones they will react sexually. If one reacts only with type I and the other only with type II, they must be of different types; but if both react with the same type, then they are alike in mating type.

This problem has been most fully studied by Kimball. In *P. aurelia* he found conjugation within a caryonide occurred under two very different kinds of conditions. One kind is very common; it occurs in caryonides genotypically of type I when the last preceding caryonide in the direct line of ancestry was type II. Under these conditions conjugation may occur in the caryonide during the first few days of its existence. Kimball split some of these conjugant pairs, tested them directly for mating type and showed that in each pair one animal was of type I, the other of type II. Thus both mating types can be present in a single caryonide and the mating is between the two types only. Kimball now obtained clone cultures from the two members of such split pairs and found in every pair that both cultures were of type I and showed no further conjugation among their own members. Hence the type II animals originally present in the caryonide changed to type I. The early occurrence of type II was due to the type II character of the immediate ancestors. This phenotypic or cytoplasmic "hang-over" fades out as the new genotype comes into action. Not all individuals accomplish this at the same speed, so for a short time some are still type II while others have completed the change to type I; at this moment conjugation may occur. A little later all have changed to type I and conjugation is no longer possible. Similar "cytoplasmic lag" in the inheritance of other characters in *Paramecium* had been reported by both De Garis and myself.

The other type of conjugation within a caryonide is of much rarer occurrence. In the race of *P. aurelia* examined by Kimball less than 3% of the caryonides showed it. In these conjugation occurred not only when the caryonide was young, but probably throughout its whole history. Moreover, any individual in the caryonide gave rise to progeny that conjugated with each other. Even the members of a split pair both gave rise to cultures in which conjugation took place. Nevertheless, Kimball found that the two members of a split pair were always of diverse mating types at the time they conjugated: one was type I, the

other type II. Hence such caryonides are unstable in mating type: it changes back and forth repeatedly; but when conjugation occurs in them it is always between animals of different mating type.

These are the only fully analysed examples of conjugation within a caryonide; but there are a number of others requiring this type of investigation. The evidence is therefore strongly against the occurrence of conjugation between animals of the same mating type, though final judgement must await full analysis of the remaining suspicious cases.

Up to this point, diversity of mating type alone has been considered as a factor determining conjugation. Are other factors also involved?

According to the well-known theory of Maupas, age is also an important factor. The exconjugant is conceived as being a young individual producing by repeated fissions immature cells unable to mate; the cells produced after many youthful fissions become sexually mature and are capable of conjugating; after more fissions, the cells grow old, losing their power of conjugating and showing other signs of senescence; and they finally die. If conjugation occurs during the period of maturity, the conjugants are rejuvenated and the cycle is renewed. In some ciliates, such as *Uroleptus mobilis* investigated by Calkins, this Maupasian life cycle is clearly shown. In *Paramecium*, however, there are striking specific and racial differences in presumably so fundamental a matter as the life cycle.

Many races of *P. aurelia* show a definite period of immaturity: during the first week or two after conjugation cultures do not give the mating reaction and cannot conjugate. In a few more days the power of conjugating rapidly develops to full strength inaugurating a period of maturity. But the organisms remain mature indefinitely; no period of senescence appears. Only during the periodically recurring processes of nuclear reorganization are they unable to conjugate for a day or so. As soon as reorganization is completed, the mating reaction reappears in full strength. Woodruff and I have shown that these periodic nuclear reorganizations prevent senescence; but why don't the reorganized cells begin again with a period of immaturity as they do after conjugation? At present this is simply a puzzling fact; probably a significant one.

Other races of *P. aurelia* not only lack a period of senescence, but also a period of immaturity: they are able to conjugate immediately after conjugation. Eight successive conjugations have been obtained in a period of 17 days. As the process of conjugation and nuclear reconstitution require one day, there could have been only about

a day between successive conjugations, a period in which at most only three or four fissions could take place. Races of this kind reduce the concept of a period of immaturity to an absurdity.

In *P. bursaria* Jennings reports a regularly occurring period of immaturity. In group I it lasts for from two weeks to several months; in group II all clones under investigation were still immature at last reports eight months after their origin at conjugation. Periods of immaturity have also been found regularly in *P. caudatum* by Gilman and in *Euplotes* by Kimball. In none of these species has there yet been any report that maturity is followed by a period of senescence with loss of ability to conjugate. Many of Jennings' clones of *P. bursaria* have been mature for over two years without loss of sexual vigor; and in this species endomixis is so rare as scarcely to account for the results.

Thus age sometimes is and sometimes is not a factor in determining conjugation; the Maupasian life cycle is not an invariable feature of ciliate life. Immaturity may be absent, short or long; maturity may be coextensive with life, or it may be simply preceded by a period of immaturity, or it may be delimited on both sides by periods of immaturity and senescence. In this respect, as in so many others, the ciliates simply refuse to conform regularly to a simple pattern.

In addition to age and diverse ancestry, Maupas recognized the importance of environmental conditions in determining conjugation. Most subsequent workers have been in more or less agreement on this point, though some such as Zweibaum and Chatton have carried this view to the extreme of ascribing to environmental conditions alone the determination of conjugation. The preceding account has shown this cannot always be true, for hereditary and developmental internal factors were demonstrated to play a decisive role in many of the races and species. To what extent then do environmental conditions operate? In *P. aurelia* nutrition, temperature and light have marked effects on the occurrence of conjugation.

The mating reaction does not take place in cultures that are either overfed or completely starved. Intermediate nutritive conditions are most favorable for its occurrence. Moreover the cultural conditions must be good in other respects: when deleterious bacteria or other unfavorable conditions make the paramecia look sickly, the mating reaction is weak or lacking.

In variety 1, the mating types I and II will react sexually at any temperature within the range examined: 9° to 32°; but the mating types III and IV of variety 2 will not react above 24°, and types V and VI of variety 3 not above 27°.

Similar differences appear in the time of day in which reactions will occur: any time will do for variety 1; but variety 2 reacts only between 6 P. M. and 7 A. M., while variety 3 reacts only between 1 A. M. and 1 P. M. As might be supposed, this periodicity is an effect of the daily alternation of light and dark. In variety 3, sexual reactivity has been completely suppressed by exposing the organisms to continuous illumination; and they have been made to react at all hours by keeping them in continuous darkness. These effects have been shown to be due to the suppression of reactivity by light, not to its stimulation by darkness.

The preceding conditions determine whether conjugation will occur when the proper mating types are brought together. Ordinarily the mating types themselves are hereditary characters; but in the exceptional unstable caryonides studied by Kimball genetic determination seems excluded for the mating types change repeatedly during vegetative reproduction. Here environmental conditions probably determine even the mating types themselves, and similar relations may be the rule instead of exceptions in species like *Blepharisma undulans* where conjugation within a caryonide occurs regularly. Parallel situations exist in the alga *Protosiphon* in which Moewus has discovered the effective environmental conditions.

Further, in certain races in which the mating types are hereditary the environment influences the genotype itself. In these races the mating types are determined by the macronuclei, all members of a caryonide being of the same mating type; but when the temperature is 9° to 14° during nuclear reorganization about 50% of the new macronuclei determine type VI, when the temperature is 18° to 25° more than 63% determine type VI, and when the temperature is 30° to 32° more than 73% determine type VI. During all subsequent fissions the temperature is without further effect, the macronucleus reproducing true to the type for which it was set during its origin. These environmental effects are naturally inherited only during vegetative reproduction, disappearing when the macronuclei are destroyed and replaced at conjugation, endomixis or autogamy. We are here probably dealing with those perplexing, long-lasting environmentally induced modifications discovered by Jollos and called "*Dauermodifikationen*".

In brief, the investigations of possible genetic, developmental and environmental factors determining conjugation show them all to be involved, as might have been expected. We now have before us the essential facts at present known bearing on the problem of individual sex differences in *Paramecium*. How are they to be interpreted?

In certain higher plants showing mating incompatibilities and self-sterility, the resulting system of breeding is sometimes much like the mating systems in species with multiple types such as *P. bursaria* and *Euplotes*. For example, in *Cap-sella* the table of possible mating combinations is the same as in a species with three interbreeding mating types. The question has therefore been raised as to whether the mating type relations in *Paramecium* are not to be considered as simple incompatibilities.

According to this view there are no sex differences between the mating types, but only between the two pronuclei that unite in fertilization. Self-sterility is shown by the failure of the two pronuclei in the same conjugant to unite, just as in the case of the self-sterile higher hermaphrodites. Further, individuals of the same mating type do not conjugate because their pronuclei are of the same self-sterile type and cannot unite.

But is it a fact, as the hypothesis assumes, that the two pronuclei in a single individual cannot unite in fertilization? Until recently all observations supported this view, but now strong evidence to the contrary is on record.

In different species of *Paramecium* Diller and Wichterman observed no exchange of pronuclei between conjugants; instead the two pronuclei formed in each conjugant united. In agreement with their cytological observations, there is some genetic evidence of non-exchange of pronuclei in *P. aurelia*, both in clones of variety 1 with visibly abnormal nuclei and possibly as a general rule in variety 2, though in the latter, the matter requires further investigation.

On the other hand, in variety 1 the genetic evidence shows that normally the pronuclei must be exchanged at conjugation. The two mating types (I and II) appear only in stocks containing the dominant gene A; when the recessive allele only is present, only one mating type, I, can appear. When the two homozygous stocks are crossed, all the exconjugants are heterozygotes, a result possible only if the dominant gene migrates from one conjugant and the recessive from the other. Similarly in crosses of heterozygote to recessive the same system is in operation. The genetic results, constituting the first proof of Mendelian heredity in the ciliate Protozoa, make it necessary to assume that the migratory pronuclei really do migrate.

Thus, although there are stocks or conditions in which the two pronuclei of the same individual unite, in variety 1 of *P. aurelia* at least the pronuclei are normally exchanged at conjugation, as is usually assumed.

Better evidence on this is obtained from studies of uniparental nuclear reorganization, where there

is no mate for nuclei to migrate into. As is well-known, Woodruff and Erdmann long ago described a periodic nuclear reorganization process in *P. aurelia* called endomixis. The macronucleus disintegrates and is replaced by a product of the micronucleus in the absence of chromosome reduction or fertilization. Diller however reports typical maturation phenomena and fertilization and therefore calls the process autogamy.

In variety 1 of *P. aurelia* it is possible to test genetically whether endomixis or autogamy is taking place at uniparental reorganizations by using the pair of genes A and a to which I have just referred. Heterozygous stocks were obtained by crossing AA by aa. These heterozygotes were then permitted to undergo nuclear reorganization and the genotypes of their vegetative progeny were ascertained by appropriate genetic methods. If endomixis had occurred, the genotypes could not have changed: all must remain heterozygotes. If autogamy occurred, the genes would be recombined yielding 1 AA: 1 aa or 1 AA: 2 Aa: 1 aa, depending upon whether the two uniting gamete nuclei arise from the same or different reduced nuclei. None of the lines tested after reorganization was heterozygotic, so none could have gone through endomixis; but $\frac{1}{2}$ were AA and $\frac{1}{2}$ were aa, in agreement with the expectations from autogamy. Further, fertilization must have been between two pronuclei descended from the same haploid nucleus in order to yield only homozygotes. Thus, in variety 1 of *P. aurelia* autogamy is the usual and possibly the only kind of uniparental reorganization. Woodruff and Erdmann's observations were mainly carried out on variety 2, which has not been tested genetically in this way; but Diller maintains that autogamy also occurs there. Probably it will be found that autogamy and endomixis take place in different races or under different conditions.

The evidences from both cytological and genetic studies at both conjugation and autogamy demonstrate that the two pronuclei formed in a single individual are perfectly capable of uniting in fertilization and do so regularly in autogamy. This seems to reduce to an absurdity the hypothesis of self-sterility in *Paramecium*: it is not only not self-sterile, but is regularly self-fertile.

With the alternative of self-sterility seemingly impossible, it appears reasonable to hold to a sexual interpretation of the mating types. If by sexual differentiation is meant the differentiation of the individuals of a species into diverse kinds so that mating occurs regularly between different kinds, never between two of the same kind, then one can scarcely avoid considering the mating types in *Paramecium* as diverse sexes. Yet there are difficulties in the way of this conclusion.

An obvious difficulty is the number of mating types in species like *P. bursaria* and *Euplotes*: are the four to eight interbreeding types in one mating system all different sexes? There are so generally just two sexes in higher organisms that some have concluded there can be but two sexes, male and female. In species where more than two sex-like types are found, every effort is made either to show they are not sexes at all or to try in some ingenious way to reduce the number to just two, and further, to identify them with male and female. Is there any prospect of succeeding in this with the mating types of *P. bursaria*, for example? Nothing now known about *Paramecium* suggests directly how this might be done, but interesting possibilities are suggested by comparison with the conditions reported in the alga *Chlamydomonas* by Moewus.

A more perplexing difficulty for the sexual interpretation of mating types arises from the apparent conflict with the idea of sex diversity in the gamete nuclei. For most investigators hold that at conjugation the migratory pronucleus is a male gamete, the stationary pronucleus a female gamete. On this view the individuals are considered hermaphroditic and so apparently could not be sexually different any more than two earthworms could be.

But numerous examples show that the criteria of male and female here employed, activity and size of gametes, are not always valid. It therefore seems prudent at least to question the validity of applying them to the gamete nuclei of *Paramecium*.

Whichever way the question is answered, the two kinds of sex diversity in *Paramecium* still must be considered in relation to each other. Calling one kind male and female does not make the other kind disappear. If one insists on calling the gamete nuclei male and female and the individuals hermaphrodites, then it simply must be recognised that even hermaphrodites may be sexually diverse with respect to their ability to unite for mating.

However, in our present state of relative

ignorance, it seems wiser to withhold the designations male and female from both the individuals and the gamete nuclei, as Maupas and Hertwig long ago, and Kniep, Mainx and others more recently have urged. The point of view most likely to be fruitful seems to me to be one in which abstract, ill-defined, and confusing ideas of fundamental maleness and femaleness are abandoned and replaced by an unprejudiced inquiry into the nature of sex diversity and sex union, both in the cell as a whole and in its nuclei. The preceding account of mating types is merely a first step in such an inquiry in *Paramecium*. The next step should be an attempt to discover the chemical differences between the mating types, as Moewus claims to have done in *Chlamydomonas*. If his results can be accepted, they are the most important recent contributions towards an understanding of sexuality in lower organisms, for they show how greatly interpretations based on purely biological analysis may be altered when the underlying chemical processes are discovered.

May I suggest that the surest value of the new knowledge of sexuality in *Paramecium* lies in what it may contribute not so much to the field of sexuality as to the field of genetics proper. Here it has provided the basic technique for controlling matings and obtaining readily the crosses necessary for genetic analysis. Lack of this has until recently greatly impeded progress in genetics of the ciliate Protozoa. With it, genes and typical Mendelian inheritance were soon found; and, by means of this, a clear demonstration of the basic nuclear processes of conjugation and autogamy. Approaches to two general genetical problems, for the study of which the ciliate Protozoa are especially favorable, have already been made: the problems of the interaction of genes and cytoplasm and of the interaction of genes and environment. On these and other general problems of genetics, the prospects for important contributions from the ciliates seem excellent.

(This article is based upon a lecture given at the Marine Biological Laboratory on July 21.)

BLOOD AND RESPIRATORY ABILITY OF FRESH WATER FISH

(Continued from page 77)

for the P_{O_2} necessary for half saturation (Table I). The facility for combining with oxygen is as great in the blood of the catfish as in the pigment myoglobin. The blood of the trout combines with oxygen even under these conditions only at about the same pressures as are necessary in oxygenation of mammalian blood. These extremes illustrate the range of properties of fish blood.

These figures apply to blood examined at 15° and at practically no pressure of CO_2 . CO_2 in-

creases the P_{O_2} necessary for oxygenation. If the increase in P_{O_2} necessary for half saturation be divided by the P_{CO_2} which effects that change in combining power for oxygen, the quotients are found to be characteristic of each species. These quotients are shown in the table (column 3), and the order of the species according to CO_2 effect agrees with the order according to P_{O_2} necessary for half saturation. This effect of CO_2 on oxygen

TABLE I.

	HbCO ₂	P _{O₂} ^{1/2} saturation	Δ P _{O₂}	Δ P _{CO₂}	Maximum CO ₂ effect
	ml/100	mm. Hg			
Lake trout	11.4				0.40
Brown trout	12.1	20	6		0.50
Rainbow trout	14.2	22	6		0.48
Brook trout	11.7	22	6		0.50
Sucker	10.6	12	3		0.58
Yellow perch	9.1				0.77
Bowfin	11.8	4	1		
Carp	12.5	5	1		0.90
Catfish	13.3	1.4	0.3		1.00

transport in the blood of fish is much greater than the Bohr effect in mammalian blood. It appears to have a much greater role in discharging oxygen from the blood in the capillaries into the tissues. In fact it serves to convert the blood of fish into a system which in the absence of CO₂ is easily loaded with oxygen at low pressures. In the tissues the low pressure of oxygen may be raised—in some species to a very large degree—by the addition of metabolic CO₂. The significance of the effect for the respiration of most fish appears so great that it is surprising that the hemoglobin of the catfish, which is quite insensitive to CO₂, has any value at all as a normal carrier of oxygen.

To determine the CO₂ effect in detail is arduous, and a shorter distinction is possible by determining the reduction in oxygen contained in blood at P_{O₂} = 150 mm. with increasing P_{CO₂}. As P_{CO₂} increases, the oxygen combined decreases

—at first rapidly, then more slowly until the limit of the effect of CO₂ is reached when the P_{CO₂} is about 60 mm. The maximum effect of CO₂ upon oxygen combining power so defined may be used as a number to define the type of blood of each species. When twelve species are so compared, the order agrees with the order according to ease of combination with oxygen.

The CO₂ effect which facilitates unloading of oxygen into the tissues would hamper loading with oxygen in the gills if any appreciable amount of oxygen were present in the water. Redfield has already shown that by a similarity property of the blood of squid respiration is prevented by CO₂. The same species of fish were placed in bottles of water with the addition of CO₂, and the effect upon utilization of oxygen observed. When the limit of oxygen utilization of each fish was plotted against the CO₂ present, each species indicated a regular and characteristic curve. The curves showed that utilization of oxygen by trout was easily impaired by CO₂ and that catfish were very insensitive. The other fish ranged between these extremes in order as the sensitivity of the blood to CO₂ would suggest.

Carbon dioxide affects respiratory ability in fish as expected from its influence upon the blood. While large amounts of CO₂ are necessary to prevent utilization of oxygen completely, small amounts of CO₂ noticeably reduce the ability of trout. The effective concentrations of CO₂ are within the range of those observed occasionally in fresh water, and it may be suggested that CO₂ would prevent the successful existence of some fish in fresh water and that it may be a factor—referable to the chemical properties of the blood—which limits the natural distribution of some species.

(This article is based upon a seminar report given at the Marine Biological Laboratory on July 18.)

THE EFFECT OF SUBSTRATE CONCENTRATION ON THE CYANIDE SENSITIVITY OF THE OXYGEN CONSUMPTION OF YEAST

DR. KENNETH C. FISHER

Assistant Professor of Experimental Biology, University of Toronto

In 1927 Warburg recorded that the oxygen consumption of baker's yeast suspended in a substrate-free medium was relatively much less susceptible to poisoning by cyanide than was the oxygen consumption in the presence of adequate concentrations of substrate. He was led to suggest, therefore, that when the respiratory surfaces of the cells were not completely saturated with substrate, the affinity of the respiratory enzyme for cyanide might be lowered by the unsaturation so that the relative effect of the poison is less under these circumstances. The suggestion seems to

have been accepted not only for the case of "saturation" in yeast, but also in a general way as a possible explanation of such changes in the relative cyanide sensitivity of respiration as are observed, for example, upon fertilisation of sea urchin eggs or upon resumption of development in the diapause eggs of the grasshopper. As there has been little or no direct demonstration of the change of affinity suggested by Warburg, we have attempted to obtain experimental evidence for it by a re-examination of the situation in yeast.

Aeration of a yeast suspension containing no

substrate brings the cells, in the course of a few hours, to a condition in which the absolute rate of respiration is greatly lowered, and in which the cyanide sensitivity is distinctly less than in the presence of substrate. Addition of *p*-phenylenediamine, a more-or-less specific substrate for a step poisoned by cyanide, increases the rate of oxygen consumption many fold and all of the increase can be prevented by cyanide. This observation suggests that the enzyme system concerned is not blocked by the absence of its normal substrate, and moreover that any change of affinity for cyanide is not of sufficient magnitude as to prevent its inhibition by that poison. It might be supposed, however, that by the addition of *p*-phenylenediamine one has in effect saturated the system again, and hence any change produced by the unsaturation might have been reversed. By modifying an experiment described by Stier a few years ago the point may be settled.

A suspension of yeast cells is aerated and the time elapsing between the stoppage of aeration and the appearance in the spectroscopy of the absorption bands of reduced cytochrome is then de-

termined. Stier has shown this interval to be directly proportional to the rate of oxygen consumption by the preparation and, as would be predicted therefore, the cytochrome reduction time increases as yeast is aerated in the absence of substrate. A preparation may be obtained in which the reduction time is fifty times that observed in the presence of substrate. In such cells the respiration can be inhibited only twenty per cent by N/100 cyanide. The same concentration of cyanide, however completely prevents the oxidation of reduced cytochrome. In saturated yeast N/1000 cyanide suffices to prevent the oxidation of reduced cytochrome so that, as Warburg suggested, a change of affinity certainly occurs as a result of unsaturation. The indication is quite clear however that the observed change of the cyanide sensitivity of the respiration is primarily due not to this change of affinity but rather to the increased relative importance of an oxygen consumption which is inherently cyanide-stable.

(This article is based upon a seminar report given at the Marine Biological Laboratory on July 18.)

A COMPARISON OF CYANIDE AND AZIDE AS INHIBITORS OF CELL RESPIRATION

MR. C. W. J. ARMSTRONG

Demonstrator in Biology, University of Toronto

In the study of cellular respiration much use is made of substances which stop catalytic activity, the inhibition in certain cases being more or less specific. Recently Keilin has reported that many of the effects of cyanide on cell respiration can be duplicated by a new inhibitor azoimide or hydrazoic acid (HN_3) which is used as the salt sodium azide. In view of the fact that several differences (Gerard, *Physiol. Rev.* 12, 1932) have already been noted in the effects produced by cyanide and carbon monoxide, which are usually considered to be more or less equivalent in their effects on cell respiration, it is important to investigate exactly how far the similarity between cyanide and this new inhibitor exists.

The effects of these inhibitors is usually believed to be due to their union with an essential enzyme, the complex being catalytically inactive. The quantitative implications of the law of mass action applied to such a reaction as this have been considered in the main only in Warburg's original work. For the present purpose, if it be supposed that one unit of enzyme (E) combines with *a* units of inhibitor (X), then, making Warburg's assumptions regarding a reversible union of the enzyme with the inhibitor one can write from the mass law,

$$\frac{[E][X]^a}{[EX_a]} = K \quad (1)$$

where K is the equilibrium constant and the square brackets indicate concentration. Transposing $[X]^a$ and taking logarithms we have

$$\log \frac{[E]}{[EX_a]} = \log K - a \log [X] \quad (2)$$

Assuming with Warburg that the respiration is proportional to the free enzyme concentration, then, when equilibrium is established after an inhibitor has been added to a respiring system the uninhibited respiration is proportional to [E] and the inhibited respiration, *i.e.*, the respiration which has been lost due to the addition of the inhibitor is proportional to $[EX_a]$, the total enzyme concentration remaining constant.

Log $\frac{\text{uninhibited respiration}}{\text{inhibited respiration}}$ plotted against log [X] should give a straight line for log K is a constant. From such a plot *a* and K can be calculated.

Previous work has shown that the embryonic fish heart beat frequency is proportional to the activity of a cyanide sensitive system and that the effect of cyanide can be quantitatively described by such reasoning as the above. The comparison of cyanide and azide was therefore made using this preparation.

Embryo fish were placed in a tube through which flowed water at constant rate and constant temperature. Under these conditions the heart rate is constant. On replacing the water with a solution of cyanide or azide the heart frequency falls to a new level (the Inhibition Level). For increasing inhibitor concentrations this Inhibition Level decreases to a level (the Maximum Inhibition Level) beyond which it is not depressed by further increases in the concentration of the inhibitor. For an intermediate concentration the proportion of the normal frequency lost due to the activity of the poison represents the inhibited frequency (respiration). The further proportion of the normal frequency which could be removed by increasing the concentration of cyanide or azide sufficiently is the uninhibited frequency, (respiration).

Log $\frac{\text{uninhibited frequency}}{\text{inhibited frequency}}$ is plotted against log inhibitor concentration and the a and K of equation (1) are derived from the straight line obtained.

Our observations on embryos of *Fundulus heteroclitus* and Atlantic salmon upon subjection to cyanide and azide can then be compared quantitatively by these respective values. The a 's so obtained are identical for one inhibitor on the two forms but the a 's for the two inhibitors are different suggesting that they act in distinctly different manners.

Keilin and others note that the degree of azide

inhibition is affected by the pH; in his experiments and in ours decreasing the pH increases the amount of inhibition. From the Henderson-Hasselbalch equation decreasing the pH is seen to result in an increase in the free acid concentration, i.e., the azoimide concentration. To investigate this phenomenon two sets of experiments were run—one at constant pH and various total azide concentrations and the second at various pH's and constant total azide concentration. Assuming that only azoimide inhibits, the mass law constants were calculated and found to agree well with each other. But it is reasonably certain that the pH inside the cell and at the enzyme surface does not change with the pH of the external medium, yet the degree of inhibition is proportional to the external azoimide concentration. The probable reason is that only free acid (azoimide) and not the salt (sodium azide) is able to enter the cells concerned and bring about inhibition.

In conclusion, three points might be emphasized:

(1) Inhibition of embryonic fish heart frequency by azide as well as cyanide admits of description by the law of mass action.

(2) The data show marked differences in the action of cyanide and azide as inhibitors, for example: (a) A difference in the Maximum Inhibition Level produced by the two inhibitors. (b) A difference in the values for a in the mass law equation for the two inhibitors, i.e., the proportion of inhibitor to enzyme in the enzyme-inhibitor combination.

(3) Finally, where pH affects the degree of azide inhibition it appears likely that the free acid and not the salt enters the cells concerned.

(This article is based on a seminar report given at the Marine Biological Laboratory on July 18.)

BOTANY CLASS NOTES

Last week was a busy one for the botanists. As usual, the Thursday evening seminar was a double feature. Dr. Goddard led off with a learned talk entitled, "The Reversible Activation of Respiration in the Ascospores of *Neurospora tetrasperma*." After the discussion which followed Dr. Goddard's lecture, Dr. Runk of the Botany course staff gave a very lucid account of his research on the fertilization, ooblastema development and cystocarp formation in *Agardhiella tenera*. Dr. Runk has painstakingly filled in the gaps in the life cycle of this familiar alga.

On Wednesday afternoon, the Algologists formed a miniature splinter fleet as the *Tern* towed us to Lackey's bay on Nonamesset in skiffs. Collecting was profitable, because although the number of species was not great, the ones

which were present were very plentiful. The class filled in several conspicuous gaps in their growing herbaria.

Monday evening culminated the social season for the botanists. The class rowed to Devils Foot Island and held a clam bake. Dr. and Mrs. Taylor were the guests of honor and Dr. Runk was the culinary expert in charge of operations. His efforts were a great success as all present will affirm. Clams and lobsters were a new experience for many, but by the end of the evening everyone was disassembling the Arthropods like an expert. The affair was a complete success, and our only regret is that it is too late in the year to hold another. A notable point is that there were no gastronomic casualties despite general overeating.

—R. Page

The Collecting Net

A weekly publication devoted to the scientific work at marine biological laboratories.

Edited by Ware Cattell with the assistance of Boris I. Gorokhoff and Mona Garman.

Entered as second-class matter, July 11, 1935, at the U. S. Post Office at Woods Hole, Massachusetts, under the Act of March 3, 1879, and re-entered, July 23, 1938.

Introducing

DR. BLODWEN LLOYD, Senior Lecturer in Bacteriology and Botany, Royal Technical College, Glasgow, Scotland; Fellow at the Woods Hole Oceanographic Institution.

Miss Lloyd's enthusiasm for America is borne out by the fact that this is her second trip to this country. Her first trip was in 1935, when she worked at the Scripps Institution during a sabbatical leave of absence from the Royal Technical College, where she was successively Assistant Lecturer in Botany, Lecturer in Bacteriology, and Senior Lecturer in Bacteriology and Botany.

Miss Lloyd studied phytoplankton at the University of Wales, where she received her M. Sc. She obtained her doctorate at the University of Glasgow, where she made, under the late Professor David Ellis, a quantitative investigation of the bacteria of the Clyde Sea area. Her research has continued along these lines; she has published thirteen articles on marine bacteriology and phytoplankton, as well as a text-book entitled, "Handbook of Botanical Diagrams". She is continuing her research at the Oceanographic Institution this summer on bacterial denitrification in the sea.

Miss Lloyd's hobby is acting; she has played in amateur representations at the College. She says smilingly that formerly she used to play the "blushing heroine," but that now she is given the rôle of the "comic aunt."

Asked for her impression of American science, Miss Lloyd commented on the wide variety of equipment supplied by American manufacturers. She found that scientists in the United States have been much less affected by the international situation than their colleagues in Europe, and that American institutions were much better endowed than those abroad. American scientists were found to be exceedingly friendly and cooperative. They fraternise more readily than in Europe. While she found American departments of biology organized to a high degree, she feels that this very degree of organization tends to stifle individual thinking. This of course is not necessarily a disadvantage, since master minds are rare in any land, and the integrated activities of groups of many workers may accomplish much more in a country of such opportunity.

OPPORTUNITY FOR BIOLOGICAL WORK AT NAPLES

DR. LAURENCE IRVING

Professor of Biology, Swarthmore College

A table is available at the Biological Laboratory, Naples, which affords the opportunity for an American biologist to work in that famous laboratory.

Uncertainties about international politics have deterred biologists from going to Naples, but these suspicions have not been justified by events. Beyond the fact that I have made this single correct observation, my opinion upon international politics is not that of an expert. But I believe that the damage from the uncertain conditions rests largely upon our readiness to be alarmed and the evil purpose which can be made of our anxiety.

Any biologist who can work to advantage at Naples should consider the idea, for several who have worked there recently give favorable reports of the material, equipment and agreeable surroundings. Dr. Ethel Harvey, Dr. Höber and Dr. Marsland will discuss their experience at Naples with any biologist who is interested.

The National Research Council has made the appropriation for the maintenance of the table at Naples on the basis of the long and notable list of biological contributions from the laboratory and with the hope that the participation of American biologists in work there will promote good international relations. Anyone who is interested in the use of the table may speak to Dr. Laurence Irving, who is chairman of the committee for awarding the use of the table. It is hoped that the use of the table will offer a valuable opportunity and a distinction to the worker as well.

CURRENTS IN THE HOLE

At the following hours (Daylight Saving Time) the current in the Hole turns to run from Buzzards Bay to Vineyard Sound:

Date	A. M.	P. M.
July 29	3:42	3:46
July 30	4:23	4:35
July 31	5:05	5:12
August 1	5:40	5:56
August 2	6:17	6:36
August 3	6:58	7:11
August 4	7:39	7:53
August 5	8:18	8:42
August 6	8:57	9:27
August 7	9:42	10:19

In each case the current changes approximately six hours later and runs from the Sound to the Bay.

ITEMS OF INTEREST

Many members of the Marine Biological Laboratory are making plans to attend the symposium on growth at North Truro which begins on Monday morning, August 7, and continues through the following Friday. Dr. O. E. Schotté will present a paper on regeneration on Thursday morning. This will be followed in the afternoon by a lecture on organization by Professor E. W. Sinnott. Among those leading the discussion will be Drs. L. G. Barth, L. B. Clark, A. B. Dawson, O. Glaser, V. Hamburger and Paul Weiss.

DR. VIKTOR HAMBURGER has been promoted from assistant to associate professor of zoology at Washington University in St. Louis.

DR. MARIE ANDERSCH has been promoted from assistant to associate professor of biochemistry at the Woman's Medical College of Pennsylvania.

DR. R. WICHTERMAN has been promoted from instructor to assistant professor of biology at Temple University.

The Chemical Room and the Apparatus Room will be closed Thursday afternoon, August 3. Investigators are urged to fill their needs before noon, August 3.

The botany seminar on July 27 was given by Dr. William Randolph Taylor, who spoke on "A Description of the 1939 Hancock Caribbean Expedition."

PROFESSOR E. E. WATSON delivered the weekly seminar at the Woods Hole Oceanographic Institution last week. The title of his paper was "Dynamic Oceanography of the Gulf of Maine."

DR. FRANK BLAIR HANSON, associate director for the natural sciences of the Rockefeller Foundation, is staying at the M.B.L. Dormitory with his wife and daughters. They will be in residence here throughout August. Their oldest daughter, Blair, recently obtained her Ph.D from the University of Wisconsin and will teach French at Allegheny College this fall. Phyllis is a junior medical student at the University of Wisconsin.

Two new investigators arrived at the Woods Hole Oceanographic Institution this week: Mrs. Helen Moore, who is bacteriologist for the Fouke Fur Company of St. Louis, which has the United States concession for taking and processing Alaskan seal furs; she is studying the marine bacteria which damage sealskins. Dr. Austin Phelps of the Department of Biology of the University of Texas, who has been given leave of absence in order to take charge of the study of the rôle of bacteria in the fouling of submerged surfaces for the Bureau of Construction and Repair of the U. S. Navy.

DR. AND MRS. P. W. WHITING left New York Tuesday on the *S. S. Nieuwe Amsterdam* to attend the International Congress of Genetics at Edinburgh.

DR. T. M. SONNEBORN left Woods Hole on Sunday following the delivery of his lecture. He will visit the World's Fair and spend a few days at the Johns Hopkins University before proceeding to Indiana University to assume his new position there.

DR. GEORGE S. DE RENYI, associate professor of anatomy at the University of Pennsylvania, and Mrs. de Renyi, have just completed a week's visit at the Frosts' on Penzance Point. They have gone to their home in New Canaan, Conn., to spend the rest of the summer.

DR. AND MRS. C. LADD PROSSER announce the arrival of a baby girl on July 23. Dr. Prosser is instructor in the physiology course at the M.B.L.

DR. KATHERINE BREHME and DR. CHARLES O. WARNER, JR., who is instructor in physiology at Cornell University Medical College, have announced their engagement and will be married in August. Dr. Brehme is finishing for the Carnegie Institution a book which was left incomplete by the sudden death of Dr. Calvin Bridges. She is working at Cold Spring Harbor. Immediately after the marriage the couple will sail for Edinburgh to attend the Genetics Congress.

DR. HARRISON E. HOWE will be the speaker at the weekly forum to be held tomorrow afternoon at 4:00 P. M. at the estate of Dr. J. P. Warbasse on Penzance Point. His subject will be, "Ersatz, or Substitute Materials in Commerce and the Arts."

The following is the program to be given at the phonograph concert at the M.B.L. Club on Monday night, July 31, 1939, at 8:00 P. M.: Sonata in A major for violin and piano (Kreutzer), *Beethoven*; Concerto No. 2 in G minor, *Prokofiev*. (Intermission). Symphony No. 4 in A minor, *Sibelius*.

M. B. L. MIXER

All members of the scientific community are invited to attend the second mixer of the current year, which will be held at 8:30 this evening at the M.B.L. Club. These mixers are held twice each summer upon the arrival of new classes, primarily in order to introduce the newly arrived students and investigators. Plans for the mixer include a general get-together, with refreshments followed by informal dancing. —C. Smith

ITEMS OF INTEREST

On Wednesday afternoon the staff of the Invertebrate Course took a trip to survey the fauna at Lackey's Bay. They were interested particularly in examining the grounds to see what changes might have been caused by the hurricane; the class makes its collecting trip there on August 1.

DR. LUANG MASYA, of the department of fisheries of Siam, was a visitor last week at the Bureau of Fisheries station.

MR. JOHN WEBSTER, of the Harvard Biological Laboratories, has come to the Bureau of Fisheries station to discover a suitable tag for tagging mackerel. He is accompanied by Mrs. Webster.

A specimen of the sting ray *Dasyatis sayi* was caught last week at the U. S. Bureau of Fisheries station. This is the first time that the fish has been caught in this vicinity. Its normal habitat is along the southern shore of the United States.

BOOK REVIEW

THE DEVELOPMENT OF THE VERTEBRATE SKULL. By G. R. de Beer. Oxford:Clarendon Press. 1937. pp. xxiii + 552. 143 plates.

In these days of the decline of morphology it is necessary, before a frankly morphological volume can be reviewed in a journal read largely by experimentalists, that the work should be outstanding; de Beer's monograph more than fulfills these requirements.

The text is divided into four sections, any one of which might have been in itself considered an adequate excuse for separate publication. The first and the two last, deal with theoretical considerations concerning the skull, its segmentation and its components. The second section, which occupies most of the book, describes with compact, and yet detailed, clarity all that is at present known of the development of the skull in every animal which has been studied. This section is illustrated with more than five hundred clear, well-labelled figures arranged on plates at the end of the volume; these are not the usual bad copies

from other writers but excellent original figures, many of which are obviously drawn from the author's own preparations.

So far these remarks might have applied to any first class morphological monograph but there are two further features which combine to place de Beer's work in a class by itself. The first is that the book concludes with a classified list of some fifty questions which urgently require further investigation: this, as the author says, in order that the "work, for all its size, will escape the lamentable fate of being regarded as exhaustive". The second outstanding feature is the bibliography which, arranged in four columns, quotes not only the author and journal but also the subject matter of the reference and the page whereon it is mentioned.

It is to be hoped, therefore, that even a busy experimentalist may have time to glance at a volume which gives not only an excellent account of its subject but also some lessons on presentation and arrangement.—*Peter Gray*.

THE MARINE INVERTEBRATE ZOOLOGY COURSE, 1939

DR. T. HUME BISSENETTE

Professor of Biology, Trinity College, in charge

The course opened on Saturday, July 29, with the usual class of 55 students, of varying degrees and stages of biological achievement from Ph.D.'s, Masters, Bachelors to Juniors in College. As usual about two-thirds are graduates already engaged in some line of research. They have been selected from over eighty applicants.

A few changes have occurred in the staff since last summer. Dr. C. E. Hadley has resigned because his services are demanded elsewhere and Dr. J. S. Rankin, Jr., has taken his place as senior instructor in charge of work on Platyhelminthes, Nemertean and Nematodes. After one year as junior instructor, Dr. W. F. Hahnert also found his services in demand at the Lake Erie Stone

Laboratory to take charge of a Freshwater Invertebrate Zoology Course. The two new faces on the staff are those of Drs. W. E. Martin, of DePauw University, and N. T. Mattox, of Miami University. Both are engaged in research on invertebrate animals.

Special lectures will be given by the staff and others on Marine Zoology, Marine Ecology and Invertebrate Phylogeny and it is hoped that other biologists working or visiting at the laboratory may be prevailed upon to lecture to us also.

In the laboratory, comparative anatomical, physiological and behavioristic studies will be made of representative marine animals from the different phyla of invertebrates found locally.

They will be taken up in the following order:—Protozoa, Porifera, Coelenterata, Ctenophora, Platyhelminthes, Nemertea, Nematoda, Annelida, Bryozoa and Calyssozoa, Mollusca, Arthropoda (including *Limulus*), Echinodermata, and Protochordata.

Field trips for the study of marine invertebrates in their habitats and associations are planned to permit students to familiarize themselves with the appearances, names and relations of the shore inhabitants from the above phyla. The following places, where varied habitats are grouped close enough together to permit several to be studied in a short time while tides are low, will be visited in the order named (*D.V.* and weather permitting): Stony or Breakwater Beach, Lackey's Bay, Lagoon Pond Bridge, Cuttyhunk, Kettle Cove, Hadley Harbor, North Falmouth and Tarpaulin Cove. Half days will be spent in the study of animals dredged up from the sound at various places as they are brought on board in the dredges and on

animals secured by sampling the sea surface layers with tow nets. Students see the methods used in such procedures. Keys for rapid identification of the more common animals of several of the phyla have been prepared by the members of the staff.

For field trips the class is divided into six teams of nine or ten members, and each member is shown how to use one or more implements on each trip to enable a team to find, identify and learn the habitat and associations of a relatively large number of species in the region visited. As nearly as possible a team is accompanied by a different instructor on each excursion. These instructors are interested in different aspects of biology and in different groups of animals. So the procedures in the field, as in the laboratory, differ with the various instructors and students profit by the influence and guidance of at least six different members of the staff on field trips and nine in the laboratory.

EMBRYOLOGY CLASS NOTES

The Martins and the Coys, those reckless mountain boys of the song, had nothing on the embryologists and the physiologists when it comes to feuds. It seems that the physiologists weren't happy about the sign that was placed behind them while they were having their picture taken. A *limulus* thrown into the embryology lab by some of their members boded no good, for a bucket of water "slipped" out the window with rather accurate aim. The subsequent calm was such as might come before a storm until a troupe of masked and aproned human forms sneaked into the lab by the back door, lined up with backs to the aquarium, took aim, and began using their misappropriated syringes to spray perfume that possibly cost \$.05 per gallon. Later, the fumes of butyric acid and pyridine seemed not to confine themselves to the waste jars of the physiologists! On the return from the towing trip Saturday morning, the embryologists found their lab suspiciously quiet and orderly, and so set to work inspecting and classifying the catch of the morning, listing members of each phylum on the black board. After nearly an hour, studious activity was broken when an observer directed his thoughtful gaze to the rafters and discovered there an additional specimen of the Phylum Chordata which was subsequently listed as a bracketed entry:

| skunk
| physiologist

Saturday afternoon found every able-bodied man warming up on the town baseball field in preparation for the much-heralded game. Despite the valient attempts of the team and its supporters

who provided oranges and energy-producing sugar, the physiologists steadily succumbed to the assault of the embryologists who stacked up a score of 39-13. Typical of the afternoon's performance was the batter who trotted around the diamond, pushing three other men home (not physiologists), and then strolled over beyond first to retrieve a lost moccasin while watching the ball relayed in from the outfield! As a token of friendship and generosity, an embryologist appeared around the corner just as the game was over, bearing the skunk on a lengthy pole. "Sweets to the sweet!"

In order that life shall not be all play, annelida, mollusca, crustacea, coelenterata, and tunicata have been developing under our microscopes during the past week. The coelenterates are furnishing a great relief after the wearisome chasing of trochophores and the attempts to catch crustacea in moments of boldness when they put velumous schnozzles out from between their shells. In addition to the lectures and laboratory direction by Dr. Hamburger, Dr. Costello, and Dr. Ballard, we have been privileged to have several special lectures. Dr. Schotté reported his own experimental work on the potencies of regenerative material and showed some very interesting slides illustrating his transplants with tadpole blastema.

Dr. E. R. Clark illustrated his talk on microscopical observation of certain embryological aspects of mammals by motion pictures of the regeneration of tissue in rabbits' ears. He and his staff were generous with time and demonstrations of work in their laboratory. Strictly scientific atti-

tudes relaxed as some petted rabbits whose ears were fitted with skillfully made chambers that allowed observation of the growing tissue. It was fascinating to watch the formation of regenerating blood vessels and lymph system as the rabbits lay calmly on the beds provided beside the microscopes. Dr. Clark's indictment of the lymph system challenged our conceptions of that extensive system and aroused considerable controversy.

An unusual quantity of mail one morning included picture post cards that Dr. Goodrich sent from Bermuda to the students at each desk. Since each of them was different, the class almost felt that they were cycling Bermuda. Earlier in the week one of the girls received the following note from him as a result of having presented him with a pineapple just as the train pulled out when he left.

Dear Miss B.—

As you were, I judge, the willing or unwilling agent of the embryology class in a remarkable presentation you are now the recipient of this note of appreciation. As in my confused state I heard no audible presentation speech, I was for a time at a loss as to the inner significance of the vegetable. It seems clear, however, that because of its well developed apical tuft it resembles a trochophore larva. There being, however, no prototroch the symbolism

must be that it indicates immaturity—of the recipient—which I, of course, welcome as being a delicate way of wishing many future years of existence before completion of the life cycle—and in this spirit I accept it with many thanks. From the more material point of view I may state that the apical tuft is now floating far out in the Atlantic with a few other axial parts—the remainder was so refreshing that I am certain it must have been a polyploid variety. (Cf. Reports of the Hawaiian Institute for Pineapple Research)

My best greetings to the Embryology Class of 1939.

Sincerely,
(Signed) HUBERT B. GOODRICH

The class is anticipating the remaining lectures of Dr. Sturtevant on "Genes and Cytoplasm," Dr. Ballard on "Tunicate Embryology," and Dr. Caswell Grave on "Ascidian Embryology." It will be with great reluctance that the budding embryologists pack up their microscopes and move out of the east wing of the old laboratory. Fascinating work tempered with lots of fun and good fellowship have made the course here an inspiring one. Any attempt to express appreciation for the fellowship, inspiration, and direction of the faculty and our worthy assistants, Gene and John, is inadequate, but sincere. Before liquidation into sentiment, adieu.

—Frances Pauls

PROTOZOOLOGY CLASS NOTES

The Protozoologists are entering into their final week of the course with slide preparations as the chief activity. Last week, gastronomical difficulties with a lobster, the first and last the NET's reporter will ever, ever touch, led to the unfortunate omission of the Protos from the pages of the NET. On Sunday, July 15 the class attended a tea given by Dr. and Mrs. Calkins. In addition to the class, present were: Dr. and Mrs. Lillie, Dr. and Mrs. Woodruff, Dr. and Mrs. Sinnott, Dr. and Mrs. Kidder, Mr. and Mrs. Claff, Miss Dewey, Miss Zimmerman, and Caswell Grave II. A most delightful time was had by all. The brownies, tea and cake were excellent as was the Deck Tennis at which Dr. Calkins easily outshone the rest.

The long awaited Protos' picnic was held on Monday the 16th, when the class together with all the research workers in Protozoology and their families journeyed to Tarpaulin Cove on Naushon. Well armed with food, the group left on the *Nereis* at 9 A. M. Before lunch many went swimming and played water polo. A modified version of dodgeball was played at which Dr. Kidder excelled. Lunch was a treat indeed with lobsters and steak as the main course, watermelon and mints for dessert. The lobsters were a new experience for many, fortunately only one proving to be allergic to them. The unanimous verdict of

the group was that it was the most enjoyable picnic they had ever been on. Mother Mamlet and her little chickadees suffered slightly with toasted epithelium for a few days afterward.

Class lectures have been mainly on vitality, and on protective adaptation, bacteria and their relation to Protozoan metabolism. Dr. Calkins' lectures on vitality have stimulated a great deal of thought on the philosophical consequences of research protozoology. Lectures by Dr. Kidder on bacteria-free cultures and their physiological significance have awakened an enthusiastic response among those who are doing research work on Protozoa at their universities. The limitation of uncontrollable factors is so greatly reduced by this technique that accurate physiological data now obtainable will cast a good deal of knowledge on many doubtful issues as work is being done. Mr. Claff's lecture and films given in the lab were greatly enjoyed.

The recent feud between Embryology and Physiology caused the innocent Protos much grief at the odoriferous butyric acid joke. Not in a joking mood, the protos will undertake their special problems by the middle of this week and before this goes to press the official termination of the course will send a few wearier and we hope wiser Protos to a well deserved rest. It's a great life if you don't awaken!

—Cecil R. Reinstein

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Mast, S. O. prof. zool. Hopkins.
Morgan, T. H. dir. biol. lab. California Tech.
Parker, G. H. prof. zool. Harvard.
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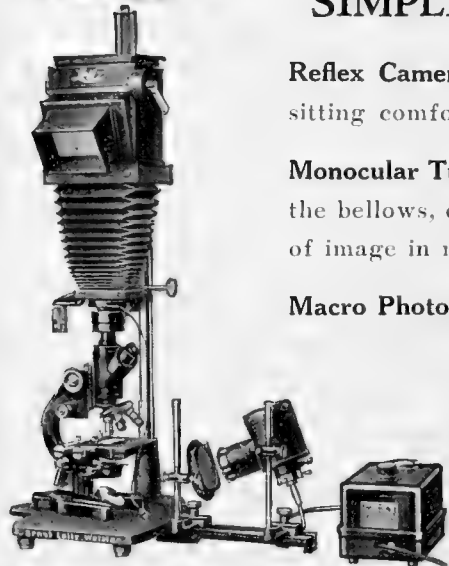
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Bartlett, L. M. asst. entom. Massachusetts State. Ka
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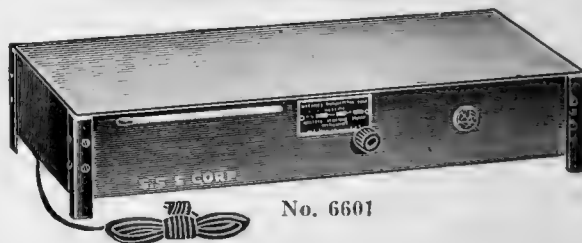
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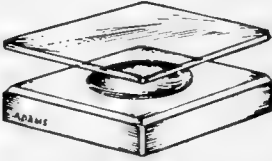
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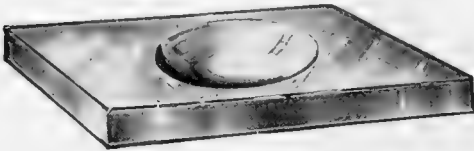
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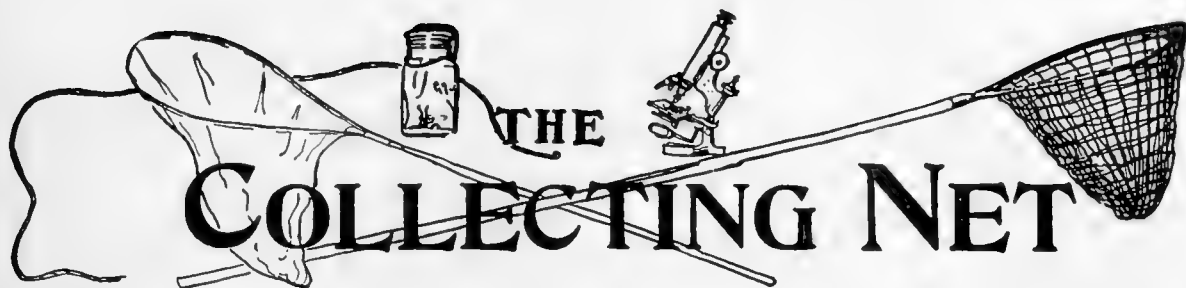
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Vol. XIV, No. 5

SATURDAY, AUGUST 5, 1939

Annual Subscription, \$2.00
Single Copies, 30 Cents.**CELL DIVISION AND DIFFERENTIATION
IN LIVING PLANT MERISTEMS**

DR. EDMUND W. SINNOTT

*Professor of Botany,
Columbia University*

The division and growth of living plant cells has been observed in hairs and filaments but never in typical meristems. Certain small-seeded grasses, which form very slender roots, also have a very poorly developed root cap, so that the terminal meristem of the root may be observed directly in living material. If seeds of such forms are germinated on moist lens paper, which is very translucent, and if this is placed on a microscopic slide and kept in a humid chamber, the seedlings may be taken out at intervals and the young, growing roots covered with a supported cover-glass and observed under high powers of the microscope. Camera lucida drawings of successive stages in the growth of the same group of cells and their descendants make it possible to study the division, growth and differentiation of cells in both the superficial layer of the root and of the layer directly beneath, and (Continued on page 107)

**CORRELATIONS BETWEEN NERVOUS
AND NON-NERVOUS STRUCTURES
DURING DEVELOPMENT**

DR. VIKTOR HAMBURGER

*Associate Professor of Zoology,
Washington University*

The primordium of the nervous system originates as a unit separate from other organ primordia. Its intimate structural relation with other organs by nerve fibers is established in later phases of development, so to speak under our eyes, unprotected from our micro-dissection instruments. This fortunate fact gives us an opportunity to study mutual developmental relations between nervous and non-nervous structures.

I wish to present evidence that the nervous system in its prefunctional period is partner in a number of mutual embryonic relations which, though physiologically different from its future functional activity, yet are of vital importance for the normal differentiation of the nervous system and of the

organs to be innervated.

The first point which I wish to take up is the analysis of the factors responsible for the pattern

M. B. I. Calendar**TUESDAY, August 8, 8:00 P. M.****Seminar:** Dr. J. D. Ferry: "The Dielectric Properties of Insulin Solutions."**Dr. J. A. Kitching:** "The Influence of Lack of Oxygen and of Low Oxygen Content on Some Protozoa."**Dr. Herbert Shapiro:** "Nerve Asphyxiation and Aerobic Recovery in Relation to Temperature."**Dr. D. A. Marsland:** "Effects of Hydrostatic Pressure Upon Certain Cellular Processes."**FRIDAY, August 11, 8:00 P. M.****Lecture:** Dr. George Wald: "Vitamins A and Vision."**TABLE OF CONTENTS**

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AERIAL VIEW OF NONAMESSET, PENZANCE POINT, AND THE ISLANDS BETWEEN

The south end of Nonamesset Island appears in the foreground with Sheep Pen Cove on the right. The islands reading from the foreground to the background are: Pine, Devil's Foot and Ram Islands. The ribbon of land in the background is Penzance Point; the tip of Dr. Warbasse's estate can be seen at the extreme left.

formation of peripheral nerves. The vertebrate limbs with their typical nerve configurations have proved to be an almost ideal object for such studies.

A priori, two explanations of pattern formation offer themselves: that the factors are intrinsic in the nerves (nerves "find" their ways themselves) or that they are extrinsic (nerves are "guided" by non-nervous structures). The latter alternative holds true.

Evidence for this can be obtained by changing experimentally the peripheral field of distribution of nerves. Detwiler devised the following experiment: In *Amblystoma* embryos in stages after determination of the fore-limb but before nerves have entered it, the fore-limb primordium was excised and reimplanted at a certain distance caudal to its normal position. The transplant was innervated however not by the neighboring trunk nerves as one might expect, but preferentially by fore-limb nerves whose course was deflected from their normal path.

This deflection suggested at once that the growth cones of the first outgrowing fibers, which are called "pathfinder" or "pioneer" fibers, might be susceptible to stimuli produced by the outgrowing bud.

That this "attraction" was not a specific relation between limb and limb nerves was shown in another experiment, in which eye or nasal primordia were placed in the same position as the limb bud in the previous experiment, after removal of the host limb. The fact that they likewise deflected nerves indicates that we are dealing with a non-specific stimulus exerted by different types of rapidly proliferating tissue. Experiments on frog embryos, in which limb nerves grew around a slit which was supposed to block their entrance into the limb, reversed the direction of their growth and eventually entered the limb, proves the same point.

We conclude that the factors responsible for the straight outgrowth of nerve fibers from the spinal chord to the basis of the limb bud reside in the limb and are extrinsic to the nerves.

The same holds for the formation of the main pathways within the limb.

Braus and many investigators following him have shown that trunk nerves and cranial nerves will enter readily into a transplanted limb where they will form a typical limb pattern. The pattern formation is determined not by the source of the nerve material but by the configuration of the non-nervous structures within the limb.

A few illustrations taken from recent material: When in the three-day chick embryo a wing bud was replaced by a leg bud, the wing nerves entered the leg and formed a typical leg pattern in the transplant. In another series, legs were transplanted anterior to the host leg. In one case the orientation of the transplant was normal; in another case it was implanted in inverted position. Incidentally the same combination of host nerves supplied the two transplants, but the patterns which they formed were mirror images of each other.

We have good evidence to show that the main blood vessels play an important rôle in "guiding" the pathfinder nerves within the limb. No such relation to blood vessels was found in the first stretch, from the spinal cord to the basis of the limb. This and other observations indicate that two different agents are operative in determining these two parts of the pattern. A third group of factors must be postulated. It would be responsible for the terminal connections; a mechanism guiding or admitting motor fibers to the muscles only, and sensory fibers to the receptors.

It is of course necessary to replace terms like "guidance" or "attraction" by physiological concepts. No conclusive evidence has been given so far that chemical or electrical stimuli are operative. Positive reactions are obtained only with "stereotropic" or "mechanical" stimuli (Harrison, P. Weiss, *et al*). The discovery of Paul Weiss that in tissue culture experiments outgrowing nerve fibers follow an artificially produced sub-microscopic structuration of the medium in which they grow, might prove to be of importance for the understanding of pattern formation *in vivo*. However, in view of the complexity of the factors involved in pattern formation, it is doubtful that one single agent will explain everything. Moreover, failure to obtain chemotropic reactions *in vitro* does not prove that they might not occur *in vivo*.

The peculiar activities and reactivities of nerve fibers which have been revealed in these experiments are obviously not related to the physiological activity of the adult fiber, the conduction of impulses.

Rather unexpectedly, it was found that the rôle of the non-nervous structures in shaping the nervous system goes further. Detwiler found that after extirpation of a limb primordium in *Amblystoma*, spinal ganglia of limb nerves showed hypoplasia, *i.e.*, a reduction in cell number. In the

chick embryo the same operation is followed by hypoplasia of the spinal ganglia as well as of the motor columns of the spinal cord. Quantitative observations based on cell counts suggest the idea that each part of the peripheral field, *e.g.*, a group of muscles, controls the quantitative development of its own nerve center by way of nerve fibers. This assumption is strongly supported by an experiment in which the peripheral areas of the brachial or lumbo-sacral plexuses respectively were overloaded by adding supernumerary limbs. Those and only those segments of the spinal cord were hyperplastic which actually innervated the transplant. We do not believe that the muscle primordia produce a growth stimulating substance which travels in a centripetal direction. We rather assume an intranervous mechanism. Nerve cells whose axones would establish peripheral connections would act as stimulators for the differentiation of potential neuroblasts which are located in their neighborhood. Grigorieff has shown in tissue culture experiments that the establishment of terminal connections induces arborization, fibrillation, and growth of the cell body of the neuron. In the case of limb extirpation, the pathfinders and their cell bodies would fail to establish terminal connections; they would, consequently, remain in a structurally and physiologically inactive condition and fail to stimulate the differentiation of neighboring nervous tissue. That one part of the nervous system may have growth stimulating effects on other parts of the nervous system has been shown repeatedly in experiments of eye extirpation and transplantation, of exchange of parts of the neural tube, etc.

Does the nervous system enter as a factor in development once the organ primordia are determined? In order to study this problem, nerveless limbs were produced in frog embryos by removing the lumbo-sacral part of the spinal cord unilaterally in neurula stages, and in the chick embryo by implanting limb buds into the coelom or to the umbilical cord.

Of the three basic components of development, morphogenesis and histological differentiation do not depend upon innervation, but growth is affected. Nerveless limbs are always reduced in size.

The possibility that blood vessels in nerveless limbs are not deprived of their autonomous innervation is not excluded. The question is therefore not settled whether we are dealing with an indirect effect by way of the control of the circulatory system or with a direct trophic effect on the tissues. The present material would offer itself for a crucial test.

The nerveless musculature develops normal cross-striation but shows progressive atrophy and, in later stages, sporadic degeneration. The nerv-

ous system is obviously necessary for the maintenance of its structure. Apparently this "trophic" effect is not limited to embryonic stages (innervated adult muscles show the same symptoms), nor to muscles. It seems to be a rather widespread phenomenon. Parker and his students have shown that taste-buds and lateral line sense organs in teleosts will promptly degenerate if deprived of their innervation.

In the skeleton, joint formation is of particular interest. Here, if anywhere, function might come into play. It is not generally realized that in the normal development of a limb all its skeletal elements are cut out of a continuous block of mesoderm. Even the joint regions proceed for a while along the line of chondrification, but are soon transformed into fibrous tissue which eventually separates, whereas the adjacent epiphyses continue their course of chondrification and ossification. In nerveless limbs, two adjacent cartilage elements were frequently found to be fused by fibrous connective tissue. However, the lines of demarcation were clearly visible in sections. This makes me think that joint formation in these nerveless limbs—which have developed, so to speak, in a permanent cast—proceed normally, but stop short of the final step, the complete separation of the two elements.

Functional activity then seems to aid in the perfection of joints, but the skeletal elements are largely self-differentiating. These observations are in full agreement with those of Murray on chorioallantoic grafts and of H. Fell on tissue cultures of knee joints.

Conclusions:

(1) Apart from its inductive capacity in the neurula and early tailbud stage the nervous system is not a causal factor in morphogenesis and histogenesis. The fact that practically all structures are prepared for functioning before their functional activity starts is one of the mysteries of development whose solution transcends experimental embryology.

(2) The well-established trophic activity of the embryonic nervous system which we found effective between nervous and non-nervous structures parallels that of the adult nervous system. It seems to be an essential, accessory function of the nervous system, probably based on a neuro-humoral mechanism.

(3) The peculiar activities of the growth cones during pattern formation are primitive biological activities *sui generis* which are, however, persistent throughout adult life because they can be activated again in nerve regeneration.

(This article is based upon a lecture given at the Marine Biological Laboratory on July 28.)

PRIMARY FILM FORMATION BY BACTERIA AND FOULING

DR. CLAUDE E. ZoBELL

Scripps Institution of Oceanography

The promiscuous assemblage of plant and animal organisms which accumulate on submerged marine structures is termed "fouling" in nautical parlance. Not infrequently a hundred or more species of animals will be found in such fouling cumulations; barnacles, hydroids, bryozoa, tunicates and sessile molluscs being the principal offenders. Certain algae commonly called "grass" or "moss" usually appear also.

Besides being of academic interest to the biologist, the fouling of submerged surfaces such as ships' bottoms, pontoons and water conduits is of great economic importance. The volume of water which will pass through a pipe line is soon materially reduced by the attachment and growth of fouling organisms in the conduit regardless of whether it is constructed of lead, concrete or other material. By increasing the resistance of ships in water as well as increasing the actual load, fouling organisms diminish the speed of a vessel, prolong the voyage, increase fuel consumption and augment the wear and tear on the machinery. Fouling organisms necessitate the drydocking of the vessel at frequent intervals for cleaning, scraping and re-painting, costly processes which take the average vessel out of commission three or four weeks each year, thereby depriving commercial carriers of revenue and interrupting the activity of other craft. The attachment of fouling organisms on their pontoons rapidly reduces the lifting power and cruising range of hydroplanes. The fouling problem is of gravest concern to the Navy in the strategem of national defense.

In studying the sequence of events in the fouling of submerged surfaces it has been observed that bacteria are the predominating primary film formers.¹ They commence to attach to clean glass slides shortly after the latter are immersed in the sea. Many of the bacteria are so tenaciously attached to the glass that they resist dislodgment when the slides are washed in running water and stained without fixation. Other bacteria are only loosely associated with the primary film and are readily dislodged unless they are fixed preparatory to staining.² Some of the bacteria actually grow on the glass slides as manifested by the development of micro-colonies.

From a few thousand to several million bacteria per square decimeter have been counted on glass slides submerged in the sea at La Jolla where the water normally contains only a few hundred bac-

teria per ml. The number and kinds of bacteria found in the primary films varies with the season, water temperature, abundance of organic matter and other environmental conditions. In less than an hour after immersion bacteria appear on clean glass slides and the number increases more or less geometrically with time until their abundance together with the simultaneous attachment and growth of diatoms, protozoa, suctoria, various larvae and detritus defeat census attempts.

Laboratory as well as field observations suggest that bacteria may play an important rôle in the fouling of submerged surfaces. In one series of experiments four to thirty times as many fouling organisms (exclusive of bacteria) were found on slides coated with films of bacteria prior to immersion in the sea as on control slides which were bacteria-free when immersed. The film-coated slides were prepared by leaving glass slides overnight in dilute nutrient solutions inoculated with cultures of marine bacteria.

Bacteria might promote the fouling of submerged surfaces in a variety of ways: (1) By affording the planktonic larval stages of fouling organisms a foothold or otherwise mechanically facilitating their attachment. (2) By discoloring glazed or bright surfaces. Visscher³ and others have shown that bright light-reflecting surfaces are fouled less readily than dark or discolored ones. (3) By serving as a source of food. It has been demonstrated that certain fouling organisms including barnacles, mussels, tunicates, and others ingest and are nourished by bacteria.⁴ (4) By protecting the fouling organisms from the toxic constituents of anti-fouling paints which are frequently used to combat the barnacle and his allies. (5) By increasing the alkalinity of the film-surface interface, thereby favoring the deposition of calcareous cements by sessile organisms. The elaboration of ammonia from the decomposition of proteinaceous materials, the reduction of nitrites or nitrates or the utilization of organic acids are bacterial processes which tend to increase the alkalinity. (6) By influencing the potential of the surface on which they are growing, bacteria might expedite the attraction and attachment of fouling organisms. (7) By increasing the concentration of plant nutrients at the expense of the accumulating organic matter which bacteria mineralize, bacterial activity tends to favor the growth of algae.

¹ Jour. Bact., 29:239 (1935).

² Jour. Bact., 32:423 (1936).

³ Bull. Bur. Fish., 43:193 (1927).

⁴ Jour. Mar. Res., 1:312 (1938).

The attachment of bacteria to submerged surfaces may be preceded and is accompanied by the adsorption and accumulation of organic matter both particulate and dissolved. This has been demonstrated by chemical as well as by biological (biochemical oxygen demand) procedures. The accumulation of organic matter is believed to account primarily for the development of bacteria on submerged surfaces, organic matter becoming much more concentrated on solid surfaces than in the sea water which contains less than 10 mgm./l. In dilute nutrient solutions exoenzymes and especially the food substances rendered assimilable by extracellular digestion diffuse away from cells as-

sociated with solid surfaces much less readily than from single free-floating cells. The interstices at the tangent of the cell and the solid surface together with the physical attraction of the solid surface tend to retain or concentrate food material in the immediate vicinity of the cell until it can be ingested and assimilated. Many bacteria are innately sessile or periphytic, preferring to grow on or growing only on solid surfaces.^{5, 6}

(This article is based upon a seminar report given at the Marine Biological Laboratory on July 25.)

⁵ Proc. Soc. Exper. Biol. & Med., 35:270 (1936).

⁶ Arbeiten Limnolog. Stat. Kossino, 21:103 (1937).

THE RELATION BETWEEN RESPIRATION AND FERMENTATION IN HIGHER PLANTS

DR. DAVID R. GODDARD

Assistant Professor of Botany, University of Rochester

Pasteur in his classical experiments on yeast established the nature of alcoholic fermentation. He also showed that the rate of fermentation was lower in air (aerobic) than in the absence of oxygen (anaerobic), and that the total sugar decomposed per unit time in air was less than in unit time in nitrogen. Since Meyerhof's beautiful work on yeast in 1925, this effect of oxygen in suppressing fermentation has been known as the Pasteur effect. In recent years the Pasteur effect has received the attention of many animal physiologists but has been little studied by plant physiologists. Three excellent reviews of the subject appeared in 1937 by Burk, Dixon, and Turner.

During the late 19th and early 20th centuries Pfeffer, Wortmann, Palladin, and Kostychev have established the fact that many higher plants liberate CO₂ under anaerobic conditions, often with an equivalent amount of alcohol produced. The ratio of anaerobic CO₂/aerobic CO₂ is often low, 1/3 or less, though frequently it is high, 1.0 or even greater. Examination of the two equations below:



shows that if the ratio is greater than 1/3 the rate of anaerobic decomposition of sugar is greater than the aerobic rate.

The experiments reported here were carried out on cortical root tissue of the common carrot (*Daucus carota*) by Mr. Paul B. Marsh and the author and will be reported in full in the *Amer. Jour. Bot.* All measurements of gas exchange were conducted in the Fenn micro-respirometer.

It is known from the literature that the ratio of alcohol/CO₂ produced by carrots in fermentation is in agreement with equation 2. We have shown

that the ratio of anaerobic CO₂/aerobic CO₂ is 1.15; indicating an anaerobic carbohydrate destruction of more than three times the aerobic rate; and establishing the existence of the Pasteur effect in carrot.

The rate of O₂ consumption and CO₂ production were measured at several partial pressures of oxygen. As the oxygen pressure is lowered from 21%, the respiratory rate begins to fall at about 5%; as the pressure is lowered to 2 1/2% and to 1% the rate of O₂ consumption falls rapidly but the CO₂ production falls less rapidly or may even increase. Thus the R. Q. (ratio of CO₂/O₂) rises from the control value of 0.85 to 3 to 3.8. If we assume that the R. Q. of respiration remains constant as respiration is inhibited, the high R. Q. indicates fermentation, and the CO₂ of fermentation may readily be calculated. No fermentation occurs until the respiratory inhibition is approximately 45% or greater, and the greater the inhibition the higher the fermentation.

Carrot root respiration is strongly inhibited (78-85%) by 10⁻³ M HCN or NaN₃ (sodium azide). 95% CO inhibits the respiration 65% and the CO inhibition is light reversible. The partition coefficient of the oxidase for CO and O₂ is 9. These results strongly indicate that the major part of the respiration is catalyzed by cytochrome oxidase.

Experiments in nitrogen indicated that 10⁻³ M HCN did not inhibit fermentation and at the same concentration the azide inhibition was slight. Fermentation in 100% CO was the same as in 100% N₂. Thus it was possible to poison respiration while fermentation was unimpaired. By use of HCN and NaN₃ fermentation could be measured in air, and with CO at oxygen pressures at which the controls showed no fermentation. As

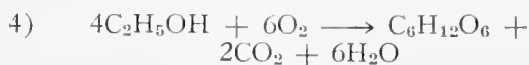
the respiratory inhibition increased from zero to 45% the R. Q. remained constant, at greater inhibitions the R. Q. rose progressively with increasing inhibition. These high R. Q. values mean fermentation. Upon removal of HCN or NaN_3 by washing, or removal of the CO inhibition with light, the respiratory rate returned to normal and fermentation was completely suppressed.

Warburg (1926) showed that in animal tumors ethyl carbylamine did not poison either respiration or fermentation, but did poison the Pasteur reaction; that is respiration and fermentation (glycolysis) both occurred at maximum rate in air. Laser (1937) has shown that in several animal tissues low oxygen tensions (5%) and CO poison the Pasteur reaction. That is, aerobic glycolysis occurred without inhibition of O_2 consumption. In carrots our experiments show that the Pasteur reaction cannot be poisoned with ethyl carbylamine, 1.0×10^{-6} to 1×10^{-4} M HCN or NaN_3 , nor is it inhibited at low oxygen tensions. Our data are insufficient to show definitely that CO does not poison the Pasteur reaction.

These experiments establish the high anaerobic fermentation in carrots and its complete suppression by respiration. Further they show that the mechanism of oxygen inhibition is by means of an enzyme system sensitive to HCN, NaN_3 and CO with light reversal, and presumably cytochrome oxidase. It is probable that in carrot there is a direct effect of respiration on fermentation. We have been unable to induce fermentation without a large decrease in respiration with low concentrations of HCN, NaN_3 , low oxygen pressures, or ethyl carbylamine. The Pasteur effect seems to be qualitatively different in plant and animal tissues.

Several explanations for the Pasteur effect have been proposed. 1) Pfeffer suggested that all carbohydrate degradation (aerobic and anaerobic) was to alcohol and CO_2 . Under aerobic conditions the alcohol was oxidized to CO_2 and H_2O . This explanation is impossible in all cases where the rate of glucose degradation by fermentation is

greater than the rate by respiration. 2) Wortmann (1879) proposed an ingenious theory of oxidative resynthesis, which is given in his equations:



Adding 3 and 4



In fermentation the reaction stops with 3, in air $1/4$ of the alcohol is oxidized and $3/4$ is resynthesized to carbohydrate. This is the first oxidative resynthesis theory in the literature. It is a possible explanation in all cases where the ratio of anaerobic CO_2 /aerobic $\text{CO}_2 \leq 1$; but is an impossible explanation where the ratio is greater than 1 as in carrots and yeast. 3) Meyerhof has proposed an oxidative resynthesis theory:



Meyerhof suggests that either the fermentation intermediate itself or an equivalent amount of carbohydrate is oxidized. Though Meyerhof's theory may not be completely proved, it is consistent with most of the evidence. The results obtained with carrots are consistent with the Meyerhof theory, but respirometer experiments in themselves will never prove the theory. 4) Lipmann has suggested that oxygen acting through a carrier may inactivate the fermentation enzymes; and that anaerobically these enzymes may be reduced by the cell and regain their activity. Our results are consistent with this theory only if the oxygen is inactivating the fermentation enzymes by way of cytochrome oxidase.

(This article is based upon a seminar report given at the Marine Biological Laboratory on July 25.)

CELL DIVISION AND DIFFERENTIATION IN LIVING PLANT MERISTEMS

(Continued from page 101)

thus to trace a rather extensive cell lineage. By use of this technique a number of developmental problems may be investigated in a typical meristem in the living condition.

(1) As a cell divides, the wall between the daughter cells tends to be situated opposite the middle of the cell in an adjacent row and never opposite an end wall of this cell. These new walls thus behave much as would liquid films, thus confirming the suggestion that in its very young state

a plant cell wall is subject to surface forces.

(2) During cell elongation the transverse walls of adjacent cells, either in the same layer or in two adjacent layers, never move past each other. This indicates that the "sliding" growth of one cell over the surface of its neighbors, often reported for plant cells, does not occur here. Microchemical tests, also, show that the walls are tightly adherent.

(3) Different portions of the wall of the same

cell may be shown to grow at different rates. This differential growth may be brought about by the retarding effect of a slowly growing cell on a part of the wall of a faster growing adjacent one, by differences between the walls near the ends and at the middle region of a cell, and by differences in the time at which the stimulus to expansion reaches different parts of a cell.

(4) The last division, in the cells of the surface layer, in certain genera, produces two cells with very different fates. The apically directed daughter cell is smaller, has more dense protoplasm and produces a root hair. The basal daughter

cell is much larger but its contents are less dense and it never forms a root hair. The degree of differentiation between these two types of cells, and the position and character of the root hairs which are formed, differ considerably in different genera of grasses.

An important factor in all these problems is the growth and differentiation of the plant cell wall, about which comparatively little is yet known.

(This article is based upon a seminar report given at the Marine Biological Laboratory on July 25.)

THE BIOLOGICAL FIELD STATIONS OF EGYPT

DR. HOMER A. JACK

Department of Science Education, Cornell University

There are two important biological field stations in Egypt: The Marine Biological Station of the University of Egypt at Ghardaqa on the Red Sea, and the Marine Laboratory of the Fisheries Research Directorate on the Mediterranean Sea at Alexandria. There is also an Institute of Desert Researches at Heliopolis, a suburb of Cairo, but apparently the important work in desert ecology is conducted, at the present, from the laboratories of the Faculty of Science of the University of Egypt at Abbassia, located on the outskirts of Cairo.

The Red Sea station is located on the edge of the Egyptian Desert, 240 miles southeast of Cairo. In the immediate vicinity of the station are various types of coral reefs, and the associated flora and fauna (including Indo-Pacific forms) are exceptionally rich. Abundant are scarlet crusts made by the foraminifera, *Homotrema*, brightly-colored patches of the leafy *Phyllospongia*, four forms of the *Hydrocoralline*, *Millepora*, several large species of *Actinia* which harbor commensal fish, large colonies of the stony corals, *Lobophyllia* and *Galaxea*, and the fleshy *Alcyonaria*, *Xenia* and *Sarcophytum*. *Echinus esculentus* is abundant on the outer reefs; the black crinoid, *Antedon*, is in the shallow waters. Also present are interesting representatives of polychaeta, molluscs, crustaceans, fishes, and certain groups of reptiles. The flora consists, in part, of a few desert forms (especially *Nitraria tridentata*), the aquatic phanerogams, *Diplanthera* and *Cymodocea*, the brown fucoids, *Sargassum* and *Turbinaria*, and the greens, *Caulerpa* and *Codium*. For further references to the taxonomy of the area see accounts of the collections of Dr. Cyril Crossland, retiring director of the station, in the *Journal of the Linnean Society* (Zoology, Vol. 31), of the Cambridge Expedition to Suez Canal in the *Transactions of the Zoological Society* (Vol. 22),

and of Dolfuss in the *Mémoires de l'Institut d'Egypte* (Vol. 21).

The station campus consists of several laboratory buildings on a pier at the edge of the shore reef, 160 yards from the beach, and the following structures on the shore: an office-museum-library, the director's residence, three resthouses for visitors, a general store, and miscellaneous buildings for employees and equipment. The laboratories are furnished with cement experimental tanks, compressed air, electricity, running sea water, common glassware, and the standard chemical and microscopical apparatus. The library contains numerous reprints, 450 bound volumes (including reports of many of the important Indian Ocean and Red Sea expeditions), and 19 different scientific periodicals. The station owns a sailboat, four smaller boats, and a 35-foot launch, the latter being equipped with a salt water pump, a winch, and the usual nets and oceanographic apparatus.

During the eight years that the station has been in operation, it has been the headquarters for more than 70 students and investigators in the biological sciences. Formal courses in biology and oceanography have seldom been given, and most of the work at the station consists of independent investigations on corals, coral reefs, and the usual problems in marine biology.

Qualified foreign investigators in the biological sciences are particularly welcomed by the station, provided they are recommended by an institution of professional standing.

The Mediterranean laboratory is at Kayed Bey, on the waterfront of Alexandria. It consists of a modern, three-story building with a public aquarium downstairs, and adequately-equipped laboratories, a library, and a museum of oceanography on the upper floors. In recent years the laboratory has had the services of the oceanographic vessel, *Mabahiss*. Expeditions with this and other ships have facilitated the publication of

a series of taxonomical studies of the fishery grounds near Alexandria. Dr. Hussein Faouzi, the director of the station, is an active member of the International Commission for the Scientific Exploration of the Mediterranean Sea, and the laboratory acts as a headquarters for such work in or near Egyptian waters. The laboratory is open to qualified investigators. Living quarters are not provided, but room and board may be ob-

tained at nearly *pensions* for as little as 30 piasters (or \$1.50) a day.

Egypt has long been a mecca for the archeologist. It might soon become a similar visiting place for the serious student or investigator in biology, for the land of the pyramids has an interesting flora and fauna, well-equipped laboratories, a genial hospitality, and an increasing proximity, in time, to America.

NUTRITIONAL SIGNIFICANCE OF NICOTINIC ACID

DR. C. A. ELVEHJEM

Professor of Agricultural Chemistry, University of Wisconsin

If we consider the status of pellagra and the antipellagra factor in 1930, we find that through the excellent work of Goldberger and coworkers pellagra had been established as a deficiency disease and the protective factor associated with the more heat stable factor of the B complex. At about this time liver extract was found to be of value in the treatment of pellagra in humans, black tongue in dogs, and in the prevention of vitamin B₂ deficiency in rats.

Shortly thereafter work on the isolation of the antipellagra factor from liver extract was initiated in the Department of Biochemistry, University of Wisconsin. Attempts to produce pellagra-like lesions in rats failed completely and the fractions were assayed with chicks placed on a heated natural grain ration. By 1935 definite evidence was available to show that the factor active in the prevention of pellagra-like lesions in the chick was separate and distinct from riboflavin, which Kuhn, György, and Wagner-Jauregg had isolated from liver and shown to have growth-promoting properties in rats. Purified fractions from liver retained their potency after complete removal of riboflavin.

Lepkovsky and Jukes at California confirmed these observations but pointed out that there was no evidence that the syndrome produced in the chick was similar to human pellagra. The work at Wisconsin was therefore repeated with dogs and again riboflavin was inactive in curing black tongue, but the concentrates free of riboflavin were highly active. In September 1937 Elvehjem, Madden, Strong, and Woolley announced that nicotinic acid was highly active in curing black tongue and that nicotinamide was isolated from the highly purified concentrates from liver extract. The rapid identification of the nicotinamide was made possible through the microanalysis of Mr. H. A. Campbell.

When nicotinic acid or the amide was tried on chicks both compounds were completely inactive. Thus the chick assay had been useful not because nicotinic acid was active in the chick, but because

the concentrates contained both nicotinic acid and the chick antidermatitis factor. The properties of the two vitamins were so similar that they followed each other in the concentrates. The rat was useful in separating the antipellagra factor from vitamin B₁, the chick for separating it from riboflavin, and the dog for establishing its relation to nicotinic acid. Work with rats has established at least two other members of the B complex, namely, vitamin B₆ and factor W.

Real success in the treatment of nutritional deficiencies will be enjoyed only when all these individual factors are recognized. Diets low in nicotinic acid or compounds which yield nicotinic acid on ingestion allow the development of pellagra, but such diets may also be low in other related vitamins. The rapid assimilation of nicotinic acid even in the presence of severe intestinal disturbances undoubtedly explains the success with which it is being used in the field. At present there appears to be no compound which is more useful. Foods containing only fair amounts of nicotinic acid are useless in the treatment of pellagra because the pellagrins are unable to digest the food sufficiently to liberate the nicotinic acid that is present.

It should be emphasized that the incidence of pellagra in certain areas of this country and other parts of the world is a temporary condition brought about by environmental conditions. Nicotinic acid as such is an emergency measure. Our goal should be the modifications of the diet so that the people in these areas would obtain sufficient nicotinic acid, as well as the other essentials, from foods. This does not mean that certain foods could not be fortified with nicotinic acid, when experimental work has shown the proper means of fortification. In any case, the great need is further knowledge of the distribution of these factors in foods. This country is still sufficiently agricultural to produce the foods adequate for a normal diet, so that we may consume pleasing foods rather than obtaining our vitamins from the drug store except in emergencies.

The Collecting Net

A weekly publication devoted to the scientific work at marine biological laboratories.

Edited by Ware Cattell with the assistance of Boris I. Gorokhoff and Mona Garman.

Entered as second-class matter, July 11, 1935, at the U. S. Post Office at Woods Hole, Massachusetts, under the Act of March 3, 1879, and re-entered, July 23, 1938.

Introducing

DR. JEAN DAVID VAN HEUVERSWYN, Assistant in the Department of Obstetrics and Gynecology, University of Liège (Belgium); Foreign Research Fellow in the Department of Anatomy at Yale University under a Belgian-American Fellowship.

Dr. Van Heuverswyn is spending the summer at Woods Hole studying and correlating research which he has done at Yale University during the past year, and discussing his work with biologists who have been studying endocrinology in the lower vertebrates.

Dr. Van Heuverswyn received his education at the Universities of Ghent and Liège, obtaining his M.D. degree at the latter institution in 1936. His graduate work had been on the permeability of nerves and the chemistry of fresh water muscels. The recipient of a travelling fellowship from the Belgian government, he worked in London at the Laboratory of Biochemistry at the Middlesex Hospital under Dr. E. C. Dodds, perfecting his technique in the study of hormones.

Dr. Van Heuverswyn arrived in America in September of last year, accompanied by his wife, Renée. He took up research at the Department of Anatomy at Yale University under Dr. Edgar Allen. He worked with different persons on various phases of reproduction; he investigated such topics as the gonad-hypophyseal relationship and cyclic osseous changes in the English sparrow, mammary growth in male mice receiving androgens and various other chemicals, and the relationship between oestrogens and cancer, the latter work being still in progress.

In May of this year Dr. Van Heuverswyn toured the United States in company with Dr. Pierre Dustin, who is sharing his room at the M.B.L. this summer. They visited universities, national parks, and other points of interest on their itinerary, which included California and Canada.

This fall Dr. Van Heuverswyn will take up research at the Department of Anatomy at Columbia University under Dr. Philip E. Smith, where he plans to study the chemistry and physiology of sex. Although his plans are still indefinite, he may return to Europe in July, 1940.

TRUSTEE NOMINATIONS POSTED

The following notice has been posted on the official bulletin board of the Marine Biological Laboratory:

August 1, 1939.

Nominations for trustees to serve until 1943.

W. C. Allee	J. H. Northrop
B. M. Duggar	W. J. V. Osterhout
L. V. Heilbrunn	A. H. Sturtevant
Laurence Irving	L. L. Woodruff

For Trustee to serve until 1940 (in place of C. R. Stockard, deceased)

W. R. Taylor

For Trustee Emeritus

G. N. Calkins

For Treasurer

Lawrason Riggs, Jr.

For Clerk

P. B. Armstrong

Nominating Committee: W. C. Allee, D. P. Costello, M. H. Jacobs, D. E. Lancefield, C. C. Speidel (chairman).

The Annual Meeting of the Corporation of the Marine Biological Laboratory will be held in the auditorium of the Laboratory on Tuesday, August 8, at 11:30 A. M., for the election of Officers and Trustees and the transaction of other business. The Trustees will convene the same morning before the Corporation meeting and again in the afternoon.

CURRENTS IN THE HOLE

At the following hours (Daylight Saving Time) the current in the Hole turns to run from Buzzards Bay to Vineyard Sound:

Date	A. M.	P. M.
August 5	8:18	8:42
August 6	8:57	9:27
August 7	9:42	10:19
August 8	10:37	11:13
August 9	11:32	.....
August 10	12:13	12:25
August 11	1:14	1:23
August 12	2:09	2:20
August 13	3:02	3:18
August 14	3:56	4:12

In each case the current changes approximately six hours later and runs from the Sound to the Bay.

ITEMS OF INTEREST

The headship of the department of anatomy at the Cornell University Medical College, left vacant by the death of Dr. C. R. Stockard, has been filled by Dr. Joseph Hinsey, professor and head of the department of physiology at the same institution.

DR. EDMOND J. FARRIS has been appointed executive director of the Wistar Institute of Anatomy and Biology, succeeding the late Dr. Milton Jay Greenman who was for many years a trustee of the Marine Biological Laboratory. Dr. Farris has been associate in anatomy in charge of operations at the Institute.

DR. THOMAS B. TURNER, of the International Health Division of the Rockefeller Foundation, has been appointed professor of bacteriology at the Johns Hopkins University School of Hygiene and Public Health.

DR. R. M. CABLE has been promoted from assistant to associate professor of parasitology at Purdue University.

DR. ELSA M. KEIL (Mrs. F. Sichel) is resigning as assistant professor of zoology at Rutgers University (New Jersey College for Women) in order to accept a position as head of the science department at the Vermont State Normal School, at Johnson, Vermont.

DR. C. D. TURNER has been promoted from instructor to assistant professor of zoology at Northwestern University.

DR. M. CATHERINE HINCHEY, who was a graduate student in biology at the University of Pennsylvania, has been appointed instructor in biology at Temple University.

DR. ALBERT MILLER, formerly of Cornell University and a member of the M.B.L. class in invertebrate zoology in 1937, is now instructor in the Department of Entomology at the University of Arkansas, Fayetteville, Ark.

ADDITIONAL INVESTIGATORS

Barden, R. B. grad. teaching asst. zool. Stanford. OM 41. K 1.

Castle, Ruth M. asst. zool. Vassar. OM 41.

Cohen, I. res. asst. Memorial Hosp. Br 344.

Gilbert, W. J. grad. asst. bot. Michigan. Bot. Dr 6.

Goulding, Helen J. Toronto. OM Phys. D 306.

Harnly, M. H. asst. prof. biol. New York. Br 321.

Hill, S. E. prof. biol. Russell Sage (Troy, N. Y.). Br 209.

Maxfield, Mary E. asst. instr. phys. Pennsylvania Med. OM Phys.

Pool, Judith de S. grad. phys. Chicago. OM Phys.

Reynolds, D. M. Harvard. Bot. K 7.

Thivy, Francesca lect. bot. Women's Christian (Madras, India). Bot.

Wilde, C. E., Jr. Dartmouth. OM 41. Dr 14.

DR. ELBERT C. COLE, professor of biology at Williams College and for several years director of the invertebrate course at M.B.L., has been elected an alumni trustee of Middlebury College for a term of five years.

DR. GIOACCHINO FAILLA, physicist at the Memorial Hospital in New York and director of the Department of Experimental Radiology at the Marine Biological Laboratory, is the recipient of the Janeway medal, awarded at the recent St. Louis meeting of the American Radium Society.

DR. GEORGE WALD, instructor and tutor in biology at Harvard University, was awarded the annual \$1,000 Eli Lilly and Company prize in Biological Chemistry for 1939 by the American Chemical Society.

Two former investigators at the Marine Biological Laboratory are among the recipients of awards from the Milton Fund of Harvard University: Dr. Karl Sax, professor of botany, for research on the effect of x-rays and neutrons on chromosomes; Dr. George B. Wislocki, Parkman professor of anatomy, for a study of the anatomy of the manatee.

PROFESSOR EMIL BOZLER, of the department of physiology of the Ohio State University, has been awarded \$250 by the Permanent Science Fund of the American Academy of Arts and Sciences for the purchase of apparatus to be used in a study of action potentials of smooth muscle. Professor William H. Cole, of the department of physiology and biochemistry at Rutgers University, has been granted \$500 by the same fund for technical assistance, materials, and special apparatus for the determination of the chemical composition of the bloods of invertebrates.

The botany seminar Thursday evening was presented by Dr. Carl Lindegren. His subject was "Neurospora Genetics."

At the staff meeting of the Woods Hole Oceanographic Institution last Thursday, Dr. N. W. Rakestraw presented a paper entitled, "The Decomposition and Regeneration of Nitrogenous Organic Matter in the Sea."

The speaker at the weekly forum at Dr. J. P. Warbasse's estate on Penzance Point tomorrow will be Mr. Frederick J. Libby, executive secretary of the National Council for the Prevention of War. The title of his talk will be, "Will Neutrality Save Us from War?"

The program to be given at the phonograph concert at the M.B.L. Club on Monday evening, August 7, is as follows: Requiem, *Gabriel Fauré*. (Intermission) Symphony in D minor, No. 9, *Beethoven*.

ITEMS OF INTEREST

The staffs of the Chemical and Apparatus Rooms held their annual picnic on Thursday afternoon and evening. The *Nereis* was run aground in the fog in Lackey's Bay on the return trip. The *Sagitta*, which happened to be following the boat, took the group aboard and brought them safely home. Captain Smith left early Friday morning with his new motorboat, *Caprice*, to retrieve the *Nereis*.

DR. H. B. GOODRICH, professor of biology at Wesleyan University, returns on Monday from a four weeks' trip to Bermuda, where he conducted research on tropical fish.

DR. ROBERT CHAMBERS, research professor of biology at New York University, returned to Woods Hole from California on July 28, but left again on Tuesday to visit in Connecticut and New York. He will return on Monday, planning to spend the balance of the summer at Woods Hole.

DR. CARL C. LINDEGREN, professor of bacteriology from the University of California, Los Angeles, arrived in Woods Hole on July 28 to converse with workers at the laboratories for two weeks. Dr. Lindegren is en route to Edinburgh where he is to participate in the program of the International Congress of Genetics. He is interested primarily in morphological characteristics of microorganisms.

DR. PAUL WEISS, associate professor of zoology at Chicago University, is working at Stanford University. He plans to spend a day or two at Woods Hole in August.

MISS ELEANOR S. BOONE, who took the embryology course in 1931, visited the laboratory at the end of last week. She is now teaching at Mills College in Oakland, California.

MISS RHEA LYON, research technician in anatomy at the University of Maryland School of Medicine, has married Dr. E. Zwilling, a teaching assistant in biology at Columbia University.

DR. KATHERINE BREHME and DR. CHARLES O. WARREN, JR., have announced their engagement; the name of the latter was incorrectly spelled in these items last week.

Science in History

A problem of scientific thought revolves about old Noah,

The question stands—was he aware of Protozoa?
Did he proclaim that he'd take two or none,

Or did he know that he could propagate with one?

—Alice Katzin

DR. B. M. DUGGAR will present a paper on September 7 at the Third International Congress on Microbiology in New York City on "The Effects of Ultra-violet Radiation on certain physiological Characteristics of *Saccharomyces* and *Phytomonas*." He will work at the laboratory until he leaves to attend the Congress.

DR. VICTOR SCHECHTER, who has been at the Marine Biological Laboratory for the past few years, is working this summer at the Scripps Institution of Oceanography.

DR. JOHN P. TURNER, who was an investigator at the Marine Biological Laboratory last summer, is teaching a course in protozoology at the Itasca Biological Station of the University of Minnesota.

DR. MADELINE PIERCE of the Department of Zoology, Vassar College, was a recent visitor at the Louisiana State University Field Laboratory. She spoke before the group on color changes in cold blooded vertebrates.

A new member of the staff of the Louisiana State University Field Laboratory for the summer is Dr. J. R. Carpenter, recently of the University of Oklahoma and from 1935-38 associated with Charles Elton of the Bureau of Animal Population at Oxford, England.

MISS NANCY ANGELL of Bryn Mawr College will work at Yale University this winter under Professor J. S. Nicholas on the functional regulation of the teleost embryo after the removal of the ear. She is the recipient of a university scholarship.

DR. A. N. SOLBERG, instructor in biology at Toledo University, has been promoted to the rank of assistant professor.

The Thirteenth International Congress of Zoology, which was to have been held this year in Rio de Janeiro, has been postponed and will be held in Paris in July or August, 1940.

The following investigators are working at the Marine Biological Laboratory under Rockefeller Foundation Fellowships: Kenneth Bailey, University of Leeds (England), who has been working with Dr. E. J. Cohn at Harvard University; R. F. Clutton, University College, London, who has been working with Dr. Hans Clarke at Columbia University; H. J. Curtis, who has been working with Dr. Philip Bard at the Johns Hopkins University School of Medicine; John A. Kitching, Bristol University (England), who has been working with Dr. E. Newton Harvey at Princeton University; Floyd Moser, who has been working with Dr. J. S. Nicholas, at Yale University.

The *Atlantis* sailed on August 3 for a trip of five or six days under the scientific direction of Dr. Edmond E. Watson, of Queen's University, Ontario. The ship will anchor south of Montauk Point in water 800 fathoms deep and test an ocean current meter devised by Dr. Watson. The *Atlantis* returned to Woods Hole on July 28 after a trip to Georges Bank to take bottom samples of submarine canyons under the direction of Mr. Henry C. Stetson. This trip was shortened by one day because of the illness of one of the members of the crew.

A general scientific meeting will be held Tuesday and Wednesday, August 29 and 30, in the Auditorium of the Marine Biological Laboratory for the presentation and discussion of work done at the laboratory during the present season. Each speaker will be limited to 10 minutes, but this time may, if desired, be divided between two papers. Additional reports, and reports presented *in absentia* may be read by title if appropriate abstracts are presented on or before Wednesday, August 23. In addition to scientific papers, demonstrations of interesting experiments, methods, etc. are invited.

The Conference on Growth and Development will open on Monday, August 7, at North Truro under the sponsorship of the editors of *Growth*, and will continue through Friday, August 11. The purposes of the symposium, according to the official announcement, is to make some progress towards bridging the gap between genetics and embryology, and towards coordinating the highly diverse findings of experimental biology for an understanding of growth and development.

Each session will be opened by the presentation of a paper, the discussion of which will be initiated by a designated leader for that topic. The following is the schedule of topics for discussion and speakers: Monday, August 7, "Cell Division and Differentiation," W. H. Lewis and P. W. Gregory. Tuesday, August 8, "Genes and Development," Curt Stern and C. H. Waddington. Wednesday, August 9, "Chemical Factors," J. Needham. Thursday, August 10, "Regeneration" and "Organization," O. E. Schotté and E. W. Sinnott. Friday, August 11, "Concept of Organism," J. H. Woodger.

The discussion will be led by L. G. Barth, H. S. Burr, L. B. Clark, A. B. Dawson, O. Glaser, H. S. Greene, V. Hamburger, L. Rapkine, K. V. Thimann and Paul Weiss.

INVERTEBRATE CLASS NOTES

Into the lab on Friday, July 28 at 7:15 P. M., we drifted in, like so much fog, to hear some words of warning and advice from Dr. Bissonnette. After introducing our instructors, Dr. Bissonnette told us of the dangers of Woods Hole—the ticks, the currents, the mold that gives one's shoes that verdant look, the temptation of working in the lab from dark till dawn, the instruments that rust in peace if one is sparing with vaseline. "Males are delivered at 12:00 noon," remarked Dr. Bissonnette. We made note of this as an interesting fact.

The following morning found us at 8:30 armed with notebooks and pens ready to plunge into protozoa with Dr. Waterman. We did—for after a brief, but meaty lecture, we drew all types of protozoa some of which we had never seen before. The Suctorina, elusive Cothurnia, and Folliculina took most of our attention.

In the afternoon we gathered in the lab preparatory to our field trip to Stony Beach. In keeping with Dr. Bissonnette's precautions, as little epithelium as possible was left uncovered, for there were more Protozoa to draw and examine and there was no time for the coddling of sunburn. We trudged to the beach in straggle formation and began our gradual immersion in the chilling waters of Buzzards Bay by turning over rocks near the shore and examining their under-

surfaces. Then we went in further just missing the eight foot drop near the rock by a hair's breadth. At the close of the afternoon even our spirits were dampened.

In the evening we went to the Mixer where we met people engaged in all sorts of activity. Conversation went like this: Stranger approaches—"Ah! you come from Turnip U. You must know Dr. Pinkus Mal du Mer!" Us—"Yes, have you heard of the results of his latest experiments on metabolism in mules?" etc.

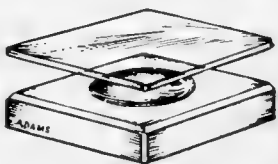
We guzzled punch with gusto and enjoyed ourselves immensely. Thank you, M.B.L. Club.

Monday Dr. Lucas introduced us to Porifera. We worked on the reunion of Microciona and obtained very satisfactory results. The identification and drawing of spicules was our despair, but the finding of choanocytes revived our enthusiasm.

Afternoon found us aboard the *Nereis* and the *Winifred* headed for Lackey's Bay and more specimens—including ticks. The finding of *Cerebratulus* was one of the high spots. *Styela*, the living atomizer, provided the usual amusement. After searching all afternoon, *Henricia sanguinolenta* was captured by Ted Walker, the Old Man of the Sea. We returned to port proud of our haul, which in most cases, totaled over 70 specimens.

—Irene Ehrmann

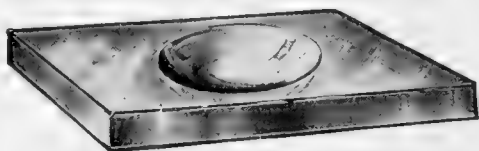
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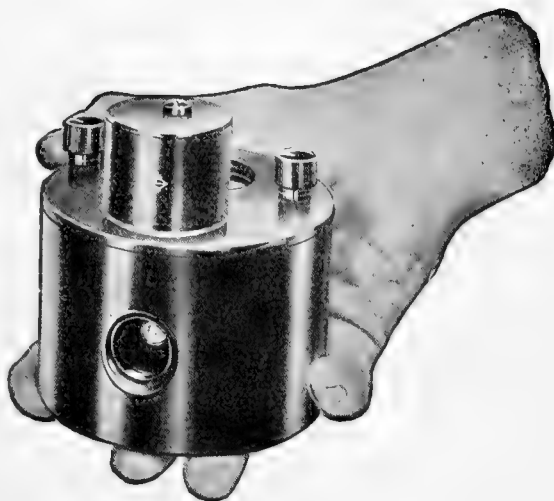
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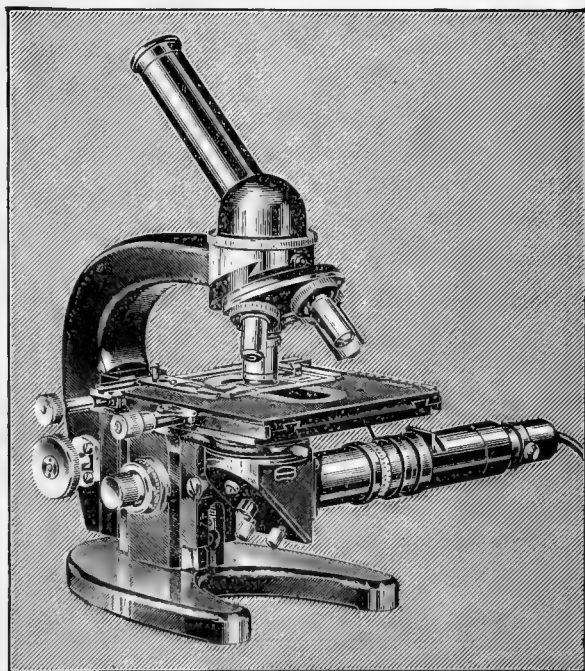
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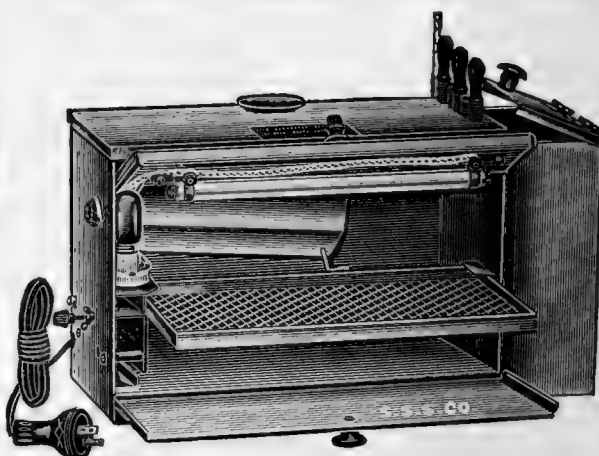
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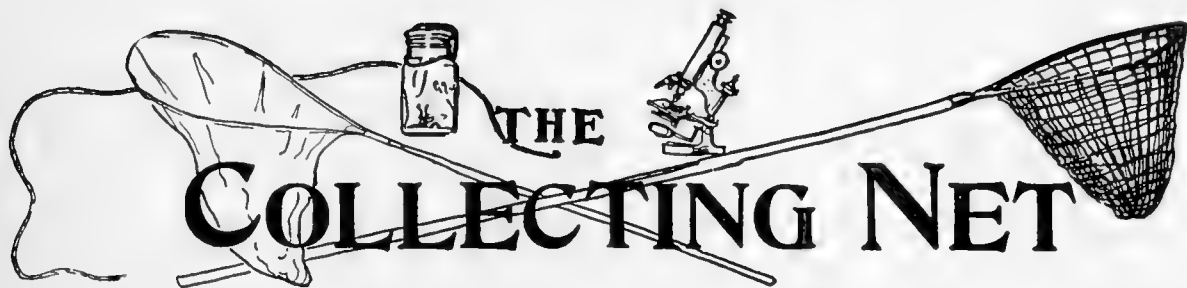
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Vol. XIV, No. 6

SATURDAY, AUGUST 12, 1939

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FUTURE PLANS AND POLICIES OF THE MARINE BIOLOGICAL LABORATORY

Report of the Trustee Committee to Formulate a Statement Concerning the Policies and Future of the Marine Biological Laboratory

I. INTRODUCTION

By way of introduction, it is important to remind ourselves of the aims of the founders of the Marine Biological Laboratory. For this purpose a series of quotations follows. It is not the intention to present a history in any detail because it will be found that the original statements of policies and aims have been carefully observed during the entire history of the Laboratory for the fifty years of its existence. As the first director early remarked, "These policies should be the germ of an indefinite future development"; and this has been the case.

In the First Annual Report of the Marine Biological Laboratory for the year 1888, the Trustees made the following statements:

"Foundation. — The Marine Biological Laboratory is an outgrowth of a sea-side laboratory maintained at Annisquam, Mass., from 1880 to 1886, by the Women's Education Association of Boston, (Continued on page 124)

NEURAL BASIS OF SOCIAL BEHAVIOR IN VERTEBRATES

DR. G. K. NOBLE

*Curator, Department of Experimental Biology,
American Museum of Natural History*

Social drives including those of dominance, sexual and parental behavior, are expressions of the activity of specific neural mechanisms which include the forebrain as the chief center of integration. Social patterns of behavior are not merely the sum of a number of simpler reflexes, but represent neural activity having rules inherent in itself. These rules may be distorted, completely modified or eliminated by removing parts of the forebrain since the remainder of the central nervous system in functioning produces new patterns of response.

At the fish level of social organization certain cohesive and disruptive forces of social behavior may be recognized. Fish schools are held together by innate attractions which are not only specific but frequently complex in nature. Fishes are

attracted by moving objects of particular sizes but each species has its own method of response. Guppies for example when frightened move away

M. B. L. Calendar

TUESDAY, August 15, 8:00 P. M.
Seminar: Dr. Grace Townsend: "On the Nature of the Material from Fertilizable Nereis Eggs Inducing Spawning of the Male."

Dr. W. C. Young: "Ovum and Spermatozoon Age at the Time of Fertilization and the Course of Gestation and Development in the Guinea Pig."

Dr. Cornelius Kaylor: "Experiments on the Production of Haploid Salamander Larvae."

Dr. A. B. Novikoff: "Regulation in Mosaic Eggs."

FRIDAY, August 18, 8:00 P. M.
Lecture: Dr. Joseph Needham: "The Metabolism of the Gastrula, with Reference to the Amphibian Primary Organiser."

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Photo by Fred S. Howard

STAFF AND STUDENTS OF THE PHYSIOLOGY CLASS AT THE MARINE BIOLOGICAL LABORATORY, 1939

Back Row, left to right: W. E. Heming, G. P. Fulton, G. M. Schoepfle, Dr. C. L. Prosser, J. M. Scott, Dr. J. A. Shannon, Dr. K. C. Fisher, J. W. Wherry, H. Von Dach, R. J. Jones, C. Hassett, C. W. J. Armstrong. Second Row: Virginia Townsend, A. B. Stimson, Dr. R. Höber, Dr. L. Irving, Dr. F. J. M. Sichel, T. T. Bell, Rosemary Martin, Judith G. de Sola Pool, Helen Timcoe. Front Row: Helen J. Goulding, Mary E. Maxfield, Mildred Bakewell, Elsa Keil Sichel, Grace Workman, Barbara Titus, Jean McVay, Priscilla Briscoe, Florence Armstrong.

from gravity; some cichlid fishes are attracted by red, other species by black objects when these objects are in motion. Some fish may be thrown into a panic by the odor of the cut skin of one of their species, with the result that injury to one individual may separate species when in mixed groups. Fish reared in isolation and then placed in mixed schools will select their own species with which to school because of the operation of a combination of these and many other innate responses.

Fish left together in groups learn to know one another personally. Even among species where there are no sexual or individual external differences which the human eye can distinguish, marking experiments reveal that the fish actually know one another personally. This is proved by the fact that these fish develop social hierarchies. Straight line "pecking orders" will form which are very similar to those of the domestic fowl described by Schjelderup-Ebbe, Allee and others. One fish can strike a second fish without being struck in return, and the second has the same right of "passing the blow" to a third individual. These hierarchies owe their existence not to strength but to psychic factors, such as the period of residence in an area. Persistent aggressive behavior of this type would soon disrupt the school if it were not the innate and learned group attractions. It is to a fish's advantage to be at the top of the peck order because the dominant fish in the long run secures more food and more mates. Many fish devote most of their energies to trying to change their social status. Individuals of a school are held together in a delicate social balance which may be permanently disrupted at a moment's notice.

In the evolution of the vertebrates, the innate species attractions of fish have given way to learned group attractions which may be readily demonstrated among birds. The learning may be accomplished very quickly as if by "imprinting" in some birds, such as the grey-lag goose described by Lorenz. That is, at certain critical stages in the life history of a bird, the individual may become attached to another and later influences do not seem to modify the bond.

At the fish level of social organization a revolution may be started in the school when any new fish is added to the group. At the bird level members of the group keep their associates in mind and attack only the newcomers at first. There is, in brief, group recognition and group solidarity. Among higher mammals the dominant individuals, although often tyrannical toward their subordin-

ates, may be looked up to by them as protectors and guides. Hence earlier students of animal sociology conceived dominance behavior as actually a cohesive force in vertebrate social organization. Among the lowest vertebrates dominance behavior is precisely opposite, for it tends to disrupt the social group. Among the highest vertebrates including man the changed attitude of the subordinate makes for greater group cohesion.

The progressive improvement in the dominance relations in the evolution of vertebrates is correlated with a shift of the centers required for social integration from the corpus striatum of fish to the cortex of mammals. A similar shift may be noted in centers required for parental behavior and for the exploratory drive. Fish without a corpus striatum are not able to exhibit any social behavior other than certain innate species attractions. Rats with a large part of the cortex destroyed are not able to retrieve young or build nests. They become stereotyped in their responses and lack the exploratory drive. At first glance this deficiency of exploratory behavior in fish and rats does not seem to have any social meaning, but since schools are continuously exploring, a fish without a corpus striatum is soon left behind in spite of the strong group attraction which remains. Similarly the loss of variability of response in mammals following lesions of the cortex leads to numerous defects of social behavior.

Lesions in the forebrain of vertebrates produce not only losses of behavior but they frequently create new behavior patterns. In the simplest case a bilateral destruction of area 8 of the cortex of the rhesus monkey has been shown by Kennard and Ectors to produce hyperactivity with resulting modification of the social patterns. In the jewel fish, certain superficial lesions of the corpus striatum will distort the pattern of parental behavior until it is identical with that in a phylogenetically more specialized group of cichlids represented by *Heterogramma*, etc. In this group of dwarf cichlids the female, although courting and spawning like other cichlids, will not permit the male to synchronize with her in the care of the eggs or young. Oddly enough the male *Heterogramma* is normally much bigger than the female, but he will be killed by his little mate if he remains near the brood. In the cases of the jewel fish with defective striata, the fights which followed numerous attempts to introduce the males following fertilization of the eggs usually resulted in the destruction of the progeny.

Although complete loss of the forebrain in fish

will result in the loss of all dominance, brooding and sexual behavior, such fish may seem in other respects more effective organisms than fish with intact brains. Thus it is known that the European minnow following removal of the forebrain responds to food more quickly. It can learn new food signals more readily, it exhibits much greater vigor in its flight reactions and it exhibits less caution and maintains its aggregations longer. In other words, the operation seems to have improved its personality, but its social relations (other than certain innate species attractions) when these are fully investigated, will be found to be completely lost if we may judge from the work on other species of fish.

Complete removal of the forebrain of fish has a detrimental effect upon the pituitary with the result that the gonads degenerate. If small rudiments of the forebrain are left, these fish may be brought to spawning by pituitary replacement therapy. However, all social patterns such as those of synchronization during spawning and brooding are lost in those fish which have suffered such an extensive destruction of the striatum.

Changes in dominance, parental, sexual and other aspects of social behavior which have taken place in the evolution of the vertebrates may have been produced, not by the addition of neural mechanisms, but by changes in the functional relations of different parts of the forebrain. Varying amounts of hormone may change the functional relation of these parts. This is well shown in the case of the black-crowned night heron which during the breeding season exhibits very different

social behavior in the two sexes; these differences are due merely to different amounts of an androgen produced in both sexes at this season. On the other hand the same brooding behavior may be produced in cichlid fishes with a wide variety of agents, including prolactin (the so-called hormone of parental behavior), proluton and even phenol. These reagents, if given in sufficient amounts, will call forth the response but will not distort it. But superficial lesions of the striatum will so exaggerate or alter the time sequence of certain components of brooding behavior that the complete pattern of response will have little resemblance to that typical of the species. Hence it would seem that while hormones may activate certain patterns of response a change in the time sequence, balance or form of the components of complex social behavior requires the normal functioning of specific parts of the forebrain.

Both brooding and dominance behavior have a genetic basis, as shown by the different types of response in the several strains of a single species, both among fishes and birds. The progressive improvement, however, which has occurred in the social behavior of vertebrates is correlated with the progressively more important rôle the cortex assumes in the social behavior of higher forms. With the extreme elaboration of the cortex in the highest primates, including man, the old innate stereotyped patterns of social response have been greatly modified or replaced by learned and intelligent behavior.

(This article is based upon a lecture given at the Marine Biological Laboratory on August 4.)

FUTURE PLANS AND POLICIES OF THE MARINE BIOLOGICAL LABORATORY

(Continued from page 121)

in coöperation with the Boston Society of Natural History. In 1886, efforts were made by the Association to place the Laboratory on an independent and broader foundation. A circular letter was addressed to many of the leading biologists of the country, reciting what had been already done at Annisquam, and asking for coöperation and counsel. The replies received were most encouraging, testifying to a general and hearty approval of the enterprise, and promising coöperation and support." (P. 7.)

"At the first meeting held by this committee, its members showed by votes that it was their desire to found a laboratory that should give opportunity for original research as well as for instruction, and soon after appointed the following trustees:

Prof. William G. Farlow, Miss Florence M. Cushing, Prof. Alpheus Hyatt, Prof. Charles S. Minot, Miss Susan Minns, Prof. William T. Sedgwick, Mr. Samuel Wells." (P. 8.)

The first announcement issued in 1888 contained the following statements:

"The Trustees of the Marine Biological Laboratory earnestly desire to enlist your co-operation in the

support of a sea-side laboratory for instruction and investigation in Biology."

"It is the desire of the Trustees that the enterprise shall enlist the active support of the universities and colleges of the country. To prevent its becoming a simply local undertaking, they wish to see all who aid in its support by subscribing to investigators' tables share with the other members of the Corporation in the annual election of Trustees. The Trustees will, therefore, invite each institution which holds an investigator's table to name five persons for members of the Corporation during the term of subscription."

Dr. Whitman commented on these statements in the Eighth Annual Report, for the year 1895 as follows:

"Here we see sketched the elemental basis of our germ-organization—mainly potentialities of a theoretical nature, but 'instinct with spirit.' The aim was a permanent biological station; the function was to be instruction and investigation; the formative principle relied upon was co-operation." (P. 19.)

Whitman himself was the most influential person

in determining the policies and aims of the new laboratory. In his first annual report as Director in 1888 he stated his personal viewpoint as follows:

"The new Laboratory at Woods Hole is nothing more, and, I trust, nothing less, than a first step towards the establishment of an ideal biological station, organized on a basis broad enough to represent all important features of the several types of laboratories hitherto known in Europe and America. It should be provided eventually with means for sending men to different points of the coast to undertake the investigation of subjects of special interest, thus adding to the advantages of a fixed station those of an itinerant laboratory.

"The research department should furnish just the elements required for the organization of a thoroughly efficient department of instruction. Other things being equal, the investigator is always the best instructor. The highest grade of instruction in any science can only be furnished by one who is thoroughly imbued with the scientific spirit, and who is actually engaged in original work. Hence the propriety—and, I may say, the necessity—of linking the function of instruction with that of investigation. The advantages of so doing are not by any means confined to one side. Teaching is beneficial to the investigator, and the highest powers of acquisition are never reached where the faculty of imparting is neglected. Teaching is an art twice blest; it blesteth him that gives and him that takes. To limit the work of the Laboratory to teaching would be a most serious mistake; and to exclude teaching would shut out the possibilities of the highest development. The combination of the two functions in mutually stimulating relations is a feature of the Laboratory to be strongly commended." (Pp. 16-17.)

In his lecture on "Specialization and Organization" (Biological Lectures, 1890) he remarked:

"Among the ways of bringing together our scattered forces into something like organic union, the most important, and the most urgent at this moment, is that of a national marine biological station. Such an establishment, with a strong endowment, is unquestionably the great desideratum of American biology. There is no other means that would bring together so large a number of the leading naturalists of the country, and at the same time place them in such intimate helpful relations to one another. The larger the number of specialists working together, the more completely is the organized whole represented, and the greater and the more numerous the mutual advantages." (P. 24.)

In 1893 he wrote in his lecture on "Work and Aims of the Marine Biological Laboratory" (Biological Lectures, 1893):

"To those who by word and example have encouraged coöperation, this record will certainly be gratifying; and perhaps it will be accepted by all as an assurance that good-will and united effort have not been fruitless. For six years the Marine Biological Laboratory has stood for the first and the only coöperative organization in the interest of Marine Biology in America." (P. 236.)

The same year he remarked in his article "A Marine Observatory the Prime Need of American

Biologists" (Atlantic Monthly, June, 1893, pp. 808-815):

"The Marine Biological Laboratory attaches itself to no single institution, but holds itself rigidly to the impartial function of serving all on the same terms. It depends not upon one faculty for its staff of instructors, but seeks the best men it can find among the higher institutions of the land. The board of trustees is a growing body, every year adding to its number, until it now comprises a very large proportion of the leading biologists of America. The whole policy is national in spirit and scope. The laboratory exists in the interest of biology at large, and not to nurse the prestige of any university or the pride of individual pretension." (P. 811.)

"Representative character, devotion to biology at large, independent government,—such are the essential elements of a strong and progressive organization." (P. 812.)

Again in 1898 he returned to the theme in an article "Some of the Functions and Features of a Biological Station" (*Science*, N.S., Vol. 7, No. 159, January 14, 1898, pp. 11-12):

"It now remains to briefly sketch the general character and to emphasize some of the leading features to be represented in a biological station.

"The first requisite is capacity for growth in all directions consistent with the symmetrical development of biology as a whole. The second requisite is the union of the two functions, research and instruction, in such relations as will best hold the work and the workers in the natural coördination essential to scientific progress and to individual development. It is on this basis that I would construct the ideal and test every practical issue.

"A scheme that excludes all limitations except such as nature prescribes is just broad enough to take in the science, and that does not strike me as at all extravagant or even as exceeding by a hair's breadth the essentials. Whoever feels it an advantage to be fettered by self-imposed limitations will part company with us here. If any one is troubled with the question: Of what use is an ideal too large to be realized? I will answer at once. It is the merit of this ideal that it can be realized just as every sound ideal can be realized, only by gradual growth. An ideal that could be realized all at once would exclude growth and leave nothing to be done but to work on in grooves. That is precisely the danger we are seeking to avoid.

"The two fundamental requisites which I have just defined scarcely need any amplification. Their implications, however, are far-reaching, and I may, therefore, point out a little more explicitly what is involved. I have made use of the term 'biological station' in preference to those in more common use, for the reason that my ideal rejects every artificial limitation that might check growth or force a one-sided development. I have in mind, then, not a station devoted exclusively to zoology, or exclusively to botany, or exclusively to physiology; not a station limited to the study of marine plants and animals; not a lacustral station dealing only with land and fresh-water faunas and floras; not a station limited to experimental work, but a genuine biological station, embracing all these important divisions, absolutely free of every artificial restriction.

"Now, that is a scheme that can grow just as fast as biology grows, and I am of the opinion that nothing short of it could ever adequately represent a national center of instruction and research in biology. Vast as the scheme is, at least in its possibilities, it is a true germ, all the principal parts of which could be realized in respectable beginnings in a very few years and at no enormous expense. With scarcely anything beyond our hands to work with, we have already succeeded in getting zoology and botany well started at Woods Hole, and physiology is ready to follow."

II. FUTURE PLANS AND POLICIES

A. *The Problem of Expansion vs. Consolidation*

Since the erection of the "New Laboratory" in 1923, there has been a steady growth in the attendance of investigators, subject to some recession during the depression, but reaching a peak in 1937 which strained our accommodations to the limit during the greater part of the session. The question is therefore forced upon our attention whether we should limit arbitrarily the number of investigators as we have long since done in the case of students in classes. The only alternative would be to increase our accommodations. Decision of this point would affect various policies, and it should therefore receive first consideration.

The Committee have given careful attention to the question of expansion and have reached the unanimous conclusion that it would be wise at this time to consolidate and develop our present plant and organization, and to postpone the question of expansion, or of new construction except as noted below under Library and under Instruction.

The main reasons for this opinion are two: first, that the problems of housing and adequate care of a considerably larger number of persons would be difficult in the restricted community in which we find ourselves, and second, the need of prudence which rests upon economic uncertainties. It is by no means certain that we may not have to face another period of depression before many years, and this should not find us over-expanded. Each of these considerations can, of course, be developed in detail.

B. *The Principle of Coöperation*

Whitman spoke of coöperation as the "formative principle" of the Laboratory. It is illustrated in the national scope of the Laboratory and in its fundamental organization and government. The principles involved in nation-wide institutional representation and coöperation, and in comprehensive membership of the Corporation, are so rooted in our practices and have proved so fruitful as to require only emphasis.

C. *Organization and Government*

The inter-relations of Trustees and Corporation

as given in the By-laws have operated harmoniously and effectively for a long time.

Rules concerning nomination and election of Trustees and members of the Corporation by the respective bodies have been formulated as follows:

1. By the Corporation:—August 11, 1931.

1) After considering various methods by which those engaged in instruction might be represented upon the Board of Trustees, it is believed that the following action by the Corporation will be the best means of insuring such representation:

"The Corporation affirms its position that instruction in course work is a fundamental part of the work of the Laboratory and should be adequately represented upon the Board of Trustees."

2) "That the Committee of the Corporation for nomination of Trustees consist of five members, of whom not less than two shall be non-Trustee members and not less than two shall be Trustee members of the Corporation."

3) "That on or about July first of each year, the Clerk shall send a circular letter to each member of the Corporation giving the names of the Nominating Committee and stating that this committee desires suggestions regarding nomination."

4) "That the Nominating Committee shall post the list of nominations at least one week in advance of the annual meeting of the Corporation."

(Memo: The same committee also makes nominations annually for Treasurer and Clerk of the Corporation.)

2. By the Trustees:—August 10, 1937.

"Proposals for membership in the Corporation shall be made to the Nominating Committee on or before the first Tuesday of August upon a regular form and endorsed by two members of the Corporation.

"With the recognition that rigid and completely standardized requirements for membership in the Corporation of the Marine Biological Laboratory are neither practicable nor desirable, it is recommended that future members of the Corporation shall, in general, be selected from among persons who, by engaging in active research at the Marine Biological Laboratory during substantial portions of at least two summers, shall have become acquainted with the work, aims, and peculiar problems of the Laboratory, and who, by papers published over a period of several years shall have demonstrated a capacity for sustained scientific productiveness not less than that required for full membership in such national societies as the

American Society of Zoologists, the Botanical Society of America, and the American Physiological Society.

"It is further recommended that in doubtful or border-line cases action on applications for membership shall be deferred until a time when, in the opinion of the Nominating Committee then serving, the status of the applicant has become entirely clear."

D. Administration

In the course of the years we have developed methods of administration of the various service departments of the Laboratory that have worked well. It should be the function of the Director and Assistant Director to control the operation of such services.

Dr. Jacobs' greatly regretted resignation as Director raises very directly the question of the higher administration. The first two Directors of the Laboratory served without salary, and the routine administration was performed by an Assistant Director on pay, at first part time but later on full time. Then Dr. Jacobs performed the services both of Director and Assistant Director on half time and half pay, and the Business Manager became able with experience to take over many of the duties formerly exercised by the Assistant Director. Though this arrangement worked admirably for the period of its duration, experience showed that it is not reasonable to expect a man of the scientific experience and reputation expected of the Director of this Laboratory to endure indefinitely the limitations of scientific activity imposed by such an arrangement. It seems probable that we cannot return to this plan.

As soon as possible we should provide for a full-time resident Director or Assistant Director. This would afford continuously supervision of the business of the Laboratory and in addition would permit this officer to continue his research work under favorable conditions. Such a resident scientist would attract other scientists during the portion of the year when the Laboratory is little used and would thus help to make it an all-year-round institution.

E. Research and Instruction

Research and instruction have been companion principles since the foundation of the Laboratory as cited in the introduction to this report. In the maintenance of research and instruction side by side throughout its history, the Marine Biological Laboratory has been outstanding, if not strictly unique. We have stood by the principle that it is the business of the Laboratory to help to produce investigators as well as investigation; and we believe that it can be shown that our courses of in-

struction have contributed in an important way to this purpose, and, moreover, that they have been an important factor in the improvement of biological instruction and research throughout the country. Although there has been some opinion among members of the Laboratory since the courses ceased to be an important source of income that we would be better off without courses, this opinion has never prevailed. We believe that our problem is in the way of improvement, not elimination, of instruction.

The Laboratory has no program of its own in research, except as defined in its name, and it therefore promotes no specific research projects as official undertakings. It operates entirely on the principle of furnishing facilities to competent investigators, and to beginning investigators who are working under qualified direction. No biological subjects are specifically excluded except such as are ruled out by lack of facilities or suitable conditions, as in the case of pathogenic organisms for example. This has been the rule from the foundation of the Laboratory, and the range of research has consequently steadily increased with improvement of facilities. Changes of fashion have of course also occurred, and are reflected in the annual reports.

The policy has been to interest the strongest biologists and promising young investigators to bring their work to Woods Hole; and the degree of success of this policy has been the measure of success and influence of the Laboratory. The future of the Laboratory depends upon the continuance of this policy, and the elimination of conditions that tend to restrict its operation, whether these are based on inadequacy of equipment, administrative regulations, or community conditions. This is the most important policy of the Laboratory, if one may be allowed to rank essentials, for it ensures leadership and reputation. To supplement this policy the attendance of as many promising young investigators as possible should be encouraged.

If the number of investigators admitted is to be definitely restricted, and if the tendency towards an increase in numbers continues, it will be necessary to adopt more definite policies concerning admission of investigators than in the past. These should not, however, be of too binding a character, but rather a definition of principles within which the Director will have free scope for the exercise of his best judgment.

The established fees for research accommodations should be continued, and paid by the institution represented as far as possible. When this cannot be done it has been a frequent policy, more in the past than at present, to waive fees for distinguished investigators. Such arrangements have often been doubly blessed, in giving and in taking.

The coöperation by institutions in the expenses of investigation of their representatives has been a strong stabilizing factor in the history of the Laboratory in more ways than one. This plan has never been more effective than at the present time, but it is important constantly to cultivate it.

The Committee recommends the continuance of our historical policy of maintaining courses of instruction. These should be contributory to research, and based upon the advantages of marine material, so that they are in no sense duplications of courses that may equally well be offered by universities. Of such courses there are several kinds. As contributory to research it is not meant that all necessarily lead directly to research as a final preparatory step, but that they may sometimes fill essential gaps in education for the kind of biological research intended by the individual. Preference for admission to courses should be given to students whose promise or declared intention indicates a professional career in the field of biology. Such students should, and do, derive great profit, not only from the actual instruction, but also from the scientific contacts that they make at Woods Hole.

The Trustees should maintain control of courses to see that proper content and principles of admission are preserved. The Executive Committee has for some time held a conference with the heads of courses each year with these purposes in mind.

Strict limitation of the numbers admitted to each course should be observed in the future as in the past. It should also be a policy to provide better and more stable laboratory accommodations.

F. Buildings, Equipment and Grounds

The first question is whether our holdings of real estate are adequate for the future. This can be answered substantially in the affirmative. We already have considerable undeveloped harbor frontage; we now own all the land on the block on which the original buildings of the Laboratory stood; in the block immediately north there is only one parcel of land on Center Street not now in our possession; and there is no immediate reason for attempting to complete our ownership of the remainder of the block. For residential purposes we still have unsold lots in the Gansett tract, and no subdivision whatever has been made of the 100 acres in the Devil's Lane Tract.

The second question concerns the buildings. Here three main needs present themselves.

In the first place, additional stack space for the library is needed. At the present rate of growth the stacks will be fully occupied in very few years. It is essential for the work of the Laboratory that this growth should be continued. Additional

space can be provided by a wing to the east of the present library. It has been suggested that the present reading room might be utilized for additional stack space and the catalogue room be converted into a reading room with other necessary readjustments; other suggestions for temporary relief have also been offered. But at most only a short postponement would be afforded in such ways. The problem should be faced and estimates secured for building additional stack space.

The second main need is to replace the present wooden buildings with a fireproof building of solid construction. The work of the classes and investigators in the wooden buildings is seriously hampered by vibration, and the buildings do not lend themselves readily to modern installations. These buildings range in age from forty to fifty years, and they constitute a real fire hazard. This need should also receive the earnest attention of the Trustees.

Additional space is also needed for various technical services necessitated by the increasing complexity of important kinds of biological research in recent years, and which are not adequately provided for at present. Among these needs are those for space for autoclaves and sterilizers, which must now be used in rooms occupied by investigators, space for stills, which are now very disadvantageously housed in the boiler room in the basement of the Brick Building, additional shop space, particularly for use by investigators for relatively simple operations which they can carry out themselves, additional space for housing small animals, dehumidified and air-conditioned rooms, additional dark rooms, etc. Doubtless most of these needs could be cared for on the lower floors of the proposed addition for the Library. They ought, in any event, not to be forgotten. Furthermore, since needs of this sort are likely to increase in future years and are less predictable than the growth of the library, ample reserve space should be provided for them.

Our waterfront should be improved by landscaping and other ways so as to furnish a dignified frontage and water approach to the Laboratory. The George M. Gray Museum should have more adequate housing, and there are numerous other desirable small improvements that should be undertaken as soon as possible.

It is becoming increasingly important that the Supply Department be enabled to collect material for research from a wider area. To this end there should be a larger motor boat, and it is highly desirable that a resident naturalist be associated with the department who could study ecological conditions from year to year with a view to establishing sources of more abundant and more varied material for research. The standing Committee

in the Supply Department should be asked to formulate the aims and policies of the Department.

G. Library

The Library Committee should be asked to formulate the aims and policies of the library.

H. Apparatus

Similarly, the Apparatus Committee should be asked to formulate its aims and policies.

I. Finances and Fiscal Policies

In 1932 the income from our endowment funds was \$55,668, representing a return of 5 per cent on book value. It is now approximately \$43,000, representing a return of 3.8 per cent on book value. The decrease in yield has been due partly to the necessity of refunding operations at lower interest rates; but the most drastic reductions in income have been suffered on the mortgage participations, some of which have been foreclosed, and others have had the interest rate much reduced. The outstanding arrears of income amounted to \$18,094 in 1935 but were reduced to \$12,775 at the end of 1937. For three years the income has been supported by payment of arrears, a condition that cannot continue indefinitely.

With a loss of annual income from endowment amounting to over \$12,000 there has been a considerable increase in attendance, which has not been compensated for by increased fees for research space. The cost of most apparatus and materials has recently risen appreciably and is likely to rise still farther. It is also certain that the progress of biological research will continually create new demands for special apparatus and equipment which must be met if the Laboratory is to retain its present position in scientific research. As a matter of fact, the budget of the Laboratory has been kept balanced since the beginning of the depression only by economies which have considerably handicapped the work of many of our investigators. Furthermore, although necessary upkeep has been maintained, certain desirable repairs to the buildings and equipment have been postponed since the early years of the depression but cannot be deferred much longer. Among the more expensive items that will require attention within the next few years are battery replacement, a new heating system for the Brick Building, repairs of the salt water system, painting and waterproofing of the brick buildings, etc. Reserves should also be built up to cover further depreciation of the buildings and equipment owned by the Laboratory, and to provide for the retirement of the Howes mortgage and for future purchases of property, etc. The problem of sewage disposal which may arise at any time is also likely to in-

volve very considerable expense.

It is clear that substantial increase of the endowment of the Laboratory is necessary if we are to aim to restore the income to its pre-depression value, to provide adequately for the upkeep of the present plant, for the establishment of necessary reserves, and to meet increasing costs of operation.

As a partial offset to the loss of endowment income since 1931, the dividends of the General Biological Supply House increased from \$2,032 in 1931 to \$12,700 in 1936. The income from fees of students and investigators cannot be increased much unless considerably higher rates are established, which seems undesirable.

The Committee agrees that the most important fiscal policies to pursue are first to increase endowment and second to establish cash reserves for depreciation and contingencies. It is fair to point out in the latter connection that cash reserves previously accumulated have been used for purchase of real estate and that considerable sums have also gone each year into capital improvements. The Committee recommends that additional endowments secured be placed in the same trusts as the present major endowment funds, or in another trust under the same principles.

J. Community Arrangements and Responsibilities

As our community has grown and assumed a more settled character, community needs have increased. The primitive needs of food and lodging have from the beginning been recognized as an official responsibility of the Laboratory; the present arrangements for low-cost housing do not appear to be entirely adequate for a community of our size. Their administration should be in the hands of the Business Manager subject to control by the superior administrative officers. An advisory committee is not recommended.

For those who desire to own their own homes, the Laboratory possesses ample real estate in the Gansett and Devil's Lane tracts, saleable to members at reasonable rates and terms. The acquisition of these tracts has aided to prevent unreasonable increase of price of village properties.

These provisions should be regarded as terminating the direct and exclusive official responsibility of the Laboratory for community purposes. While the Laboratory should aid in securing recreational facilities, the responsibility for operating them should be in the hands of the community itself. This principle has operated well in the case of the "M. B. L. Club" and the "M. B. L. Tennis Club." The Laboratory has furnished land and buildings, and from time to time has made loans for improvements, and it may yet appear desirable to provide an addition to the building of the M. B. L. Club. But these organizations should operate

under their own membership and fees. With the acquisition of the bathing beach the question arises whether the same principles could not be made to operate there.

K. Summary of Principal Recommendations

1. That the Marine Biological Laboratory pursue a policy of consolidation rather than expansion for the present.
2. That in pursuit of this policy steps be taken to provide the following major improvements:
 - a. Secure additional funds for endowment.
 - b. Provide additional stack room to accommodate approximately 100,000 additional volumes, together with study cubicles.
 - c. Replace present wooden laboratories by a building, or buildings, of stable fireproof construction, providing an intermediate court to set off the present main building
 - d. In connection with the library construction provide adequate space for expansion of various technical services as described in II F.
 - e. Make provisions for the series of miscellaneous needs enumerated in the body of the report.

3. Maintain the principles of coöperation (II B.), organization and government (II C.), administration (II D.), research and instruction, (II E.), that have served so well in the past, as the basis for future development.
4. Additional endowment funds as received should be placed, like the present main endowment funds, in trust. Reserves for depreciation, contingencies, improvements and retirement fund should be set up out of income (II I.).
5. Responsibility for recreational facilities should be placed as far as possible on voluntary organizations within our scientific community (II J.).

(At its meeting on August 11, 1937, the Board of Trustees authorized the President to appoint a committee to formulate this statement on the Plans and Future of the Marine Biological Laboratory. The members of this Committee were: E. G. Conklin, Chairman, G. N. Calkins, W. C. Curtis, H. B. Goodrich, M. H. Jacobs, T. H. Morgan, G. H. Parker, A. C. Redfield and C. R. Stockard. After many discussions during the summers of 1937 and 1938 a report was drawn up by Dr. Lillie which was studied and amended by the Committee. This article is a section of the annual report of the director of the Marine Biological Laboratory published in the August issue of "The Biological Bulletin.")

MUSCLE PROTEINS

DR. KENNETH BAILEY

Leeds University and the Imperial College of Science, England

The present trend of biochemical research emphasises increasingly the importance of the protein molecule in the life process. The muscle proteins, which contribute so much to human dietary needs, are no less important than those protein entities known to have a specific enzymatic, hormonal or virus activity, for their properties indicate that they are connected with the contractility of muscle itself. The pioneer workers of the last century, embodying such names as Kühne, Danielowsky, von Fürth and Halliburton, made many fundamental observations on the protein components of skeletal muscle, but left the field in a somewhat confused state; the protein fractions described under the terms myosin, myosinogen, myogen, soluble myogen fibrin and so on were defined with conflicting properties. It is only in recent years that a clear picture of the protein system in skeletal muscle has emerged, and other muscle types have still to be investigated.

The main protein component of muscle, studied anew by Edsall¹ is the globulin myosin, extracted from freshly excised muscle by salt solutions at pH 7; on dilution of the extract to a salt molarity of 0.07 the myosin precipitates in the form of a

thixotropic gel, but further dialysis deposits a second globulin, termed by Weber globulin X. The latter is completely precipitated at molarities of about 0.0004, leaving in solution an albumin, myogen. Globulin X and myogen probably provide a serious medium—the sarcoplasm—surrounding the fibrils.² A proximate assay of the proportion of these various proteins together with the stroma proteins, reveals, in the case of mammalian and fish muscle, that myosin is the main protein component.^{3, 4}

The properties of myosin are extremely anomalous; its sols are very viscous, and unlike myogen and globulin X, possess anomalous viscosity and exhibit double refraction of flow. When the sol is diluted the thixotropic gel so obtained slowly denatures on standing, and coagulates on warming to 45°. In the muscle itself the myosin undoubtedly exists in the gel state and the molecule—known to be thin and thread-like rather than spherical—may well be as long as the anisotropic band of muscle itself; but when the gel is dispersed in salt solutions, the resulting sol is

² Pflüg. Arch. ges. Physiol., 235:205 (1934).

³ Proc. Roy. Soc. B., 124:136 (1937).

⁴ Biochem. J., 33:255 (1939).

¹ J. Biol. Chem., 89:289 (1930).

polydisperse and the average particle weight is of the order of a million. If the sol is dried on a glass plate, a tough resilient film of denatured protein is obtained, which like wool and hair shows a certain amount of reversible elasticity; when placed in steam it exhibits supercontraction, a phenomenon associated with the keratins after breakage of salt and disulphide links. Moreover, it has been demonstrated by Dr. Astbury that the film after some slight stretching gives the characteristic X-ray diffraction pattern of α -keratin, and after further stretching there is an intra-molecular transformation to the β -keratin configuration.⁵ These X-ray data indicate that in the final denatured state, myosin consists essentially of long parallel polypeptide chains in which the main dimensions of the polypeptide grids are practically coincidental with those of keratin. We imagine the undenatured molecule on the other hand as consisting of long hydrated polar chains in a partially contracted state; if these are brought within a critical distance of each other by thermal agitation (warming to 45°) or by dehydration with organic solvents, the richly charged side chain groups will cohere to form an insoluble, denatured micelle. For this reason, Astbury has defined myosin as a protein configurationally disposed to denaturation. These properties of myosin, which make it rather an unique molecule, standing half way between the fibrous insoluble keratins and collagens, and the globular, soluble proteins which constitute most of the proteins in the animal and vegetable kingdoms, must in some way be related to the process of muscle contraction, and one can think of no better mechanism than the contraction and elongation of each and every polypeptide chain itself. Indeed, the X-ray diffraction patterns of living muscle lend support to this hypothesis.⁶

The universality of myosin in muscular tissue raises the interesting teleological question whether the myosins of different orders and species have a fundamental amino-acid make-up; in mammals and birds, this appears to be the case, but in fish and crustaceans there are deviations which suggest that although the general order of magnitude of each individual amino acid constituent is the same, minor variations are possible without any great change in the physico-chemical characteristics of the molecule.⁷

The remaining proteins of muscle are not so well defined as myosin; whether globulin X is derived from some other protein component is still open to question, although it does differ markedly from myosin in the absence of streaming double refraction and in the loss of salt solubility after

treatment with dilute acids. Again, the preparation of myogen by current dialysis methods is entirely unsatisfactory since myogen is unstable in salt free solutions. Recently in these laboratories I was able to obtain the myogen of rabbit muscle in crystalline form and this was considered to be the first major protein component crystallised from muscle. Almost simultaneously the crystallisation of two forms of myogen was reported by Baranowski from the laboratory of Parnas.⁸ The first form, termed myogen A, is obtained by an elaborate fractionation of muscle press juice, the procedure involving a heat treatment at 50° ; myogen B, the second form, crystallises somewhat fortuitously from the mother liquor. Whilst A crystallises as hexagonal bipyramids, B is obtained in the form of long thin plates and appears identical with the product obtained here, and prepared by fractionation of a salt extract of muscle. In our method the A form has not been observed. Whether A and B are merely crystalline modifications of the same proteins, or whether the production of the A form is connected with Baranowski's heat treatment, remains to be determined: certainly, some unpublished results on the crystalline globulin edestin of hemp seed indicate that heating may change the polarity of the protein surface without concomitant denaturation. The main point to be stressed, however, is that these crystallisations open up an almost infinite field of research in the realm of comparative biochemistry, involving not only a comparison of the myogens of different species and different orders, but the comparison of muscle albumin with the crystalline serum albumins. In the infinitely complex system of living muscle we are indeed fortunate in obtaining two, if not three, protein entities from a limited number of protein components.

⁸ Zeit. Physiol., 260:43 (1939).

(This article is based upon a seminar report given at the Marine Biological Laboratory on August 1.)

PROFESSOR VAGN WALFRID EKMÁN, formerly professor of mechanics and mathematical physics at the University of Lund, Sweden, will deliver three lectures at Woods Hole this month. The dates and titles of his lectures are as follows: *August 16*, "Purposes of Dynamic Oceanography;" *August 17*, "Some Experiments and Remarks about the Structure of Ocean Currents;" *August 22*, (title to be announced later). Dr. Ekman will arrive at Woods Hole this week-end for a stay of about two weeks. He has come to the United States to attend the meeting of the International Union of Geodesy and Geophysics in September.

⁵ Nature, 135:95, 765 (1935).

⁶ Ann. Rev. Biochem., 8:113 (1939).

⁷ Biochem. J., 31:1406 (1937).

The Collecting Net

A weekly publication devoted to the scientific work at marine biological laboratories.

Edited by Ware Cattell with the assistance of Boris I. Gorokhoff and Mona Garman.

Entered as second-class matter, July 11, 1935, at the U. S. Post Office at Woods Hole, Massachusetts, under the Act of March 3, 1879, and re-entered, July 23, 1938.

Introducing

DR. JOHN ALWYNE KITCHING, Lecturer in Experimental Zoology, University of Bristol (England); Rockefeller Foundation Fellow at Princeton University.

Dr. Kitching's paper at the seminar last Tuesday evening, on the effects of lack of oxygen and low oxygen tension on the general activities of Protozoa, deals with the work that he has been conducting in the United States. Upon his arrival in this country last September, he began this problem at Princeton University with Dr. E. N. Harvey under a Rockefeller Foundation fellowship; he is continuing it at the Marine Biological Laboratory.

Osmotic changes in Protozoa have interested Dr. Kitching for many years; his Ph.D. thesis (University of London, 1933) was concerned with these changes with especial reference to contractile vacuoles. He continued research on the physiology of these vacuoles during the following years, when he was lecturer in zoology at Birkbeck College, London. In 1937 he became a lecturer in experimental zoology at the University of Edinburgh; in the fall of the same year he joined the faculty of the University of Bristol.

Aside from physiology, Dr. Kitching has been interested in seashore ecology, a field in which several of his eleven papers have been published. He has been working in Great Britain with a diving outfit, and has conducted under-water explorations along the coasts of England and Scotland, with a view to determining the distribution of organisms between the low water level and a depth of forty feet, particularly along rock shores where it is impractical to use drag-nets.

Aside from diving, Dr. Kitching's favorite hobby is sailing. He is accompanied by his wife, Evelyn, and their children, Jean and David, and has just been joined by his mother who recently arrived in America. In September the group will return to England on the S. S. *Samaria*.

SUPPLEMENTARY DIRECTORY

Addison, W. H. F. prof. normal histol. & emb. Pennsylvania. OM 40.
 Beam, C. A. Brown. OM 21. K 12.
 Davenport, D. instr. biol. Reed (Portland, Ore.). OM Phys.
 Fulton, G. P. teaching fel. biol. Boston U. OM Phys.
 Jones, R. J. asst. phys. Buffalo Med. OM Phys. K 9.
 Lipman, H. J. grad. asst. biol. Pittsburgh. Rock 7.
 Musser, Ruth E. Goucher. Br 109. H 3.
 Naumann, R. V. fel. phys. New York Med. Br 321.
 Phelps, Lillian A. asst. biol. New York. OM 12.
 Wherry, J. W. grad. asst. phys. Northwestern. OM Phys. Ka 22.
 Wintrobe, M. M. assoc. med. Hopkins Med. L 21.

DATES OF LEAVING OF INVESTIGATORS

Angell, Nancy	July 29
Armstrong, C. W. J.	August 7
Briscoe, Priscilla M.	August 7
Copeland, E.	July 28
Curtis, H. J.	August 1
deMarinis, F.	August 2
Dieter, C. D.	August 3
Erlanger, Margaret	July 22
Fisher, K. C.	August 2
Furth, J.	July 31
Hairston, N. G.	July 28
Herget, C. M.	August 1
Höber, R.	August 4
Keefe, E. L.	August 7
Lee, L.	August 3
Milford, J. J.	July 28
Molter, J. A.	August 5
Morrill, C. D.	August 4
Nabrit, S. M.	August 3
Norris, C. H.	August 5
Prescott, G. W.	July 31
Prosser, C. L.	August 1
Rose, S. M.	August 1
Runk, B. F.	July 31
Sayles, L. P.	August 1
Scudamore, H. H.	August 5
Shannon, J. A.	July 20
Taft, A. E.	July 31
Van Cleave, C. D.	August 5
Walker, P. A.	August 2

CURRENTS IN THE HOLE

At the following hours (Daylight Saving Time) the current in the Hole turns to run from Buzzards Bay to Vineyard Sound:

Date	A. M.	P. M.
August 12	2:09	2:20
August 13	3:02	3:18
August 14	3:56	4:12
August 15	4:44	5:06
August 16	5:33	5:57
August 17	6:23	6:44
August 18	7:15	7:36
August 19	8:02	8:35
August 20	8:54	9:30
August 21	9:51	10:25

In each case the current changes approximately six hours later and runs from the Sound to the Bay.

ITEMS OF INTEREST

At the Corporation meeting of the Marine Biological Laboratory on Tuesday, Dr. John H. Northrop, member of the Rockefeller Institute for Medical Research, was elected a trustee for four years, replacing Prof. Gary N. Calkins who was made trustee emeritus. The trusteeship left vacant by the death of Dr. Charles R. Stockard was filled by the election of Dr. Wm. Randolph Taylor, professor of botany, University of Michigan. A report of the meetings of the Board of Trustees and of the Corporation by Dr. Packard will be printed in the following issue of THE COLLECTING NET.

An informal meeting of scientific advisors of the Wistar Institute of Anatomy and Biology was held in the Marine Biological Laboratory yesterday. Those taking part in the conference were Drs. Esmond R. Long, *President of the Institute*, Alfred N. Richards, George B. Wislocki, J. S. Nicholas, George W. Corner, and D. H. Tennent.

Among those who came to Woods Hole this week to attend the meeting of the Board of Trustees of the Marine Biological Laboratory were: Drs. H. C. Bumpus, E. G. Conklin, W. C. Curtis, Otto Glaser, H. B. Goodrich, L. V. Heilbrunn, W. B. Scott, and D. H. Tennent.

DR. G. KINGSLEY NOBLE, curator of herpetology and of experimental biology at the American Museum of Natural History in New York City, has been appointed visiting professor of biology in the Graduate School of New York University. He still retains, however, his position at the Museum.

DR. M. J. KOPAC, formerly a research worker in the biology department of New York University, has been appointed visiting assistant professor of biology at the Graduate School there.

At the Oceanographic staff meeting last Thursday, Dr. H. R. Seiwel presented a paper entitled, "Internal Waves."

The annual exhibit of the work of the pupils at the Children's School of Science was held yesterday afternoon in the schoolhouse. The annual meeting of the School was held on the same afternoon.

A photographic demonstration and lecture will be given at the Marine Biological Laboratory on Thursday, August 17, by Mr. Frank L. Mason of Cambridge, Mass. He will demonstrate "Fine Grain Development," at 4:30 P. M. in the Old Lecture Hall; at 7:30 P. M. he will speak on "Kodachrome and Special Processes" in the Auditorium. Appointments may be made with Mr. Mason for discussions of special problems.

The *Atlantis* will sail on Monday to take routine determinations on the strength of the Gulf Stream under the direction of Dr. Alfred Woodcock. It will also take mud cores of off-shore areas for Mr. Henry Stetson who is conducting a general study on the sea-bottom. The ship returned on Thursday morning from a trip to test out a current meter devised by Dr. Edmond E. Watson. A particular study was made on this trip of the allowance which must be made in current observations for the swinging of the ship at anchor.

Last week-end Dr. Claude E. ZoBell visited the Mount Desert Island Biological Laboratory at Salsbury Cove, Maine, and the Marine Biological Laboratory of the University of New Hampshire on the Isles of Shoals, N. H.

DR. E. ALFRED WOLF, associate professor of biology at the University of Pittsburgh, made a short visit to New York late this week.

DR. PAUL S. GALTISOFF, acting director of the United States Bureau of Fisheries station in Woods Hole, left on Tuesday to visit the Bureau station in Milford, Connecticut. He returned on Thursday evening.

DR. RICHARD WEISSENBERG, member of the Wistar Institute, arrived in Woods Hole on August 8 for a stay of two weeks. He worked at the Marine Biological Laboratory in 1937.

DR. MARTIN KNUDSEN, professor of physics at the University of Copenhagen, was a visitor at the Woods Hole Oceanographic Institution last Tuesday. Dr. Knudsen is in the United States to attend the Washington meeting of the International Union of Geodesy and Geophysics.

DR. R. WICHTERMAN, assistant professor of biology at Temple University, arrived at Woods Hole with his family on August 4. He had previously been at the Tortugas Laboratory.

The present and former members of the Osborn Zoological Laboratory of Yale University who are at Woods Hole this summer were entertained at tea on August 4th by Professor and Mrs. L. L. Woodruff at their home on Agassiz Road. Among those present were Dr. and Mrs. E. J. Boell, Dr. T. K. Ruebush, Dr. and Mrs. W. R. Duryee, Dr. and Mrs. Austin Phelps, Dr. and Mrs. F. Moser, Dr. and Mrs. E. Scharrer, Dr. E. Frances Botsford, Dr. O. Schotté, Mr. and Mrs. G. W. Molnar, Mr. J. D. Ifft, Mr. G. G. Robertson, Dr. and Mrs. A. L. Colwin, Miss Bridgman, Dr. Jane Oppenheimer, Dr. N. S. R. Maluf, Mr. T. S. Hall, Mr. E. W. Opton, Mr. Alfred Compton.

ITEMS OF INTEREST

Members of the National Academy of Sciences working at the Woods Hole Biological Laboratories this summer are: G. N. Calkins, F. R. Lillie, T. H. Morgan, G. H. Parker, L. L. Woodruff, B. M. Duggar, M. H. Jacobs, E. W. Sinnott, A. H. Sturtevant, H. B. Bigelow, E. F. DuBois, E. N. Harvey, P. Rous, and L. Loeb.

Several members of the Woods Hole Oceanographic Institution are planning to present papers at the meeting of the International Union of Geodesy and Geophysics, which will begin in Washington on September 6. Among those planning to give papers are Mr. Columbus O'D. Iselin, Dr. H. R. Seiwel, Prof. A. F. Spilhaus, and Mr. Floyd M. Soule.

CHEMICAL AND HISTO-CHEMICAL OBSERVATIONS ON *MACRACANTH-ORHYNCHUS HIRUDINACEUS*

DR. THEODOR VON BRAND

Professor of Biology, Barat College of the Sacred Heart, Lake Forest, Ill.

The investigation was undertaken in order to secure data about the chemical composition of a representative of the acantocephala, a group very specialized in body structure and well adapted to parasitic life, very little being known about this. The females of *Macracanthorhynchus hirudinaceus* were chosen because of their size and their relatively easy accessibility.

The worms contained relatively small amounts of dry substance, consequently the figures for inorganic substances, nitrogen, glycogen and ether extract were somewhat lower than usually found in other helminths. Chemical analyses showed that by far the greatest part of glycogen was located in the body wall, whereas relatively less fat was stored there. In the reproductive cells, on the other hand, a relatively much larger part of the total ether extract than the glycogen was found.

Since it was not possible to subject isolated tissues to a chemical analysis, the exact localisation both of glycogen and fat were studied with differential staining methods. A large amount of poly-

saccharide was found in the hypodermis, where it occurred along the fibers and in the interior of the lacunar system. Much glycogen was also found in the muscles, especially those connected with the proboscis and the reproductive organs. The center of fully developed embryos was very rich in glycogen, whereas immature eggs and ovaries contained no, or but little, polysaccharide. Some glycogen was also located in the nervous system and the excretory system.

Fat droplets demonstrable by osmic acid were found in the hypodermis, but they did not enter the lacunae. Important storage places were the ovaries, the ground substance of which was entirely filled with fat droplets, whereas the cells themselves were fat free or at least very poor in fat. This latter applies also to the mature and immature eggs. A certain amount of fat was also found in some muscles and parts of the reproductive tract.

(This article is based upon a seminar report given at the Marine Biological Laboratory on August 1).

THE IONIC PERMEABILITY OF FROG SKIN AS DETERMINED WITH THE AID OF RADIOACTIVE INDICATORS

DR. LEONARD I. KATZIN

Research Fellow in Zoology, University of California

Potassium ion is commonly said to increase the permeability of tissues. In the course of recent investigations of the effects of potassium chloride on the electrical potentials of frog skin, the suggestion was made that the effects of this salt could be explained in terms of a high relative rate of diffusion through the skin rather than a permeability change. The availability in this laboratory of radioactive isotopes of the common elements afforded the means of direct test of this suggestion. This was done as follows.

Pieces of frog skin were fastened across the ends of glass tubes, and small volumes of the radioactive solutions tested were placed in the tubes. Distilled water was placed on the outside of the skin, and the relative amount of radioactive

salt which passed across into the outer solution was given by the radioactivity as measured with the Geiger-Müller counter.

Various mixtures of radioactive sodium chloride with potassium chloride were measured, ranging from pure NaCl to mixtures containing 90% KCl and 10% NaCl. More restricted experiments made use of active RbCl and inactive NaCl mixtures. The results can be seen in Table I. Here the quantities in parentheses are estimated values or are derived from estimated values. The permeability values given are relative figures in which the permeability to the pure salt is taken as unity. The absolute values for the pure salts are obtained from comparison with the activity of solutions of known concentration. Sodium ion passes from the

TABLE I

Frac. NaCl	1/1	3/4	2/3	1/2	1/4	1/10	0/1
Rel. perm.	1.0	1.0	1.1	1.15	1.6	1.8	(2.0)
Frac. RbCl	0/1	1/4	1/3	1/2	3/4	9/10	1/1
Rel perm.	(0.5)	(0.5)	(0.65)	0.66	0.7	—	1.0
Rb/Na	(13)	(13)	(15)	15	11.4	—	(13)
R (calc.)	10,700	312	—	103	91	—	36
NaCl:	4.7×10^{-12} mols sec ⁻¹ cm ⁻² (H ₂ O outside)						
RbCl:	125×10^{-12} mols sec ⁻¹ cm ⁻² (H ₂ O outside)						

isotonic solution of the pure chloride through the skin into distilled water at the rate of 4.7×10^{-12} gram ions per second per square centimeter, while rubidium ion penetrates at the rate of 125×10^{-12} gram ions per second per square centimeter. This shows that pure RbCl passes through the frog skin membrane 26-27 times as rapidly as does NaCl.

We can show that this is not due to an increase in permeability of the skin. Taking, for example, the case in which we have equimolar mixtures of NaCl and KCl (or RbCl and NaCl), we see that the permeability of the skin to sodium ion has changed only some fifteen per cent, while the rubidium ion penetrates at a rate fifteen times as great. It is obvious that here we are not dealing with a change in permeability induced by the KCl, but a difference in rate of passage of the two ions. We can also see that although the permeability to sodium approximately doubles in going from pure NaCl to pure KCl solutions, the ratio of the permeability of rubidium ion to sodium ion remains relatively constant. The permeability ratios for rubidium and sodium in Table I assume that RbCl and KCl are equivalent in their effects.

This technique can also be used in testing the question of irreciprocal passage of salts across the skin. It is only necessary to put isotonic sodium chloride on both sides of the skin and to compare the rates of passage of the radioactive ions from inside out and outside in. It has been possible to show that the rate of inward passage of sodium ion is some sixty-four per cent higher than the rate of outward passage.

From the permeability data it is also possible to essay a calculation of the electrical resistance of the tissue in the various solutions, on the assumption that these salts are the principal carriers of current in the system. This can be done by integrating the Fick equation

$$dS = -Dq \left(\frac{dc}{dx} \right) dz$$

under the additional assumption that the concentration gradient is linear and may be represented by c/w , where c is the concentration of the internal solution and w is the thickness of the skin; for D we may substitute the value derived in 1888 by Nernst,

$$D = k \left(\frac{uv}{u+v} \right),$$

where k is a known function of the temperature, and u and v are the mobilities of the cation and anion respectively. We may simplify the resulting expression by substituting $u = av$. Solving for v , one obtains

$$v = \frac{-Sw(1+a)}{akqcz} \text{ and } u = \frac{-Sw(1+a)}{kqcz}.$$

The specific conductance of an electrolyte solution is given by

$$K = c(u+v);$$

substituting the above values of u and v and inverting we obtain the specific resistance of the tissue. The resistance of the thickness w would then be equal to w times the specific resistance or a resistance

$$R = \left(\frac{kqz}{-S} \right) \cdot \frac{a}{(1+a)^2} \text{ ohms.}$$

The expression for the resistance of a mixture of salts is slightly more complicated, but can be obtained through the additivity of the conductances of the separate salts.

If we can evaluate S and a , we can calculate a theoretical resistance for the skin immersed in a given solution, and the extent of agreement with experimental values will furnish a check upon the adequacy of our fundamental postulate; namely, that the salts whose penetration we are measuring

are the principal carriers of the electrical current. For the purpose of simplicity we may assign S the values determined experimentally for the amount of salt which has passed through the membrane, ignoring that portion which may be present in the tissue itself. It is to be pointed out that the validity of this assumption may be questionable if the whole of the diffusion-limiting layer of the tissue is equally permeable, and of considerable thickness.

If we assume a value of 8 (or $1/8$) for a , we obtain a value of slightly over 10,000 ohms for the resistance of a square centimeter of skin in contact with isotonic NaCl. This is ten to one hundred times the experimental values which can be found in the literature for direct current or low frequency alternating current resistance. The values for R found in Table I have been calculated using the value $a = 8$. It must be pointed out that with the use of radioactive indicators it is possible to evaluate the cation-anion mobility ratio experi-

mentally; this is the first item on our program at present.

The disagreement of our calculated values of the skin resistance with the few experimental determinations available may be due to any of several factors: (1) the ions with which we are concerned may not be the principal carriers of electrical current; (2) the proportion of diffused radioactive salt present in the tissue may be significant, and not to be ignored; (3) the differences of ion mobility through the tissue may be even greater than the arbitrary value we have taken; (4) the diffusion gradient may vary significantly from linearity. Further experiments will show which of these factors are important. That there actually exists a difference in mobilities through the skin must be self-evident from the gross differences in rate of passage of rubidium and sodium ions from mixtures with a single anion.

(This article is based upon a seminar report given at the Marine Biological Laboratory on August 1.)

THE ISLES OF SHOALS MARINE ZOOLOGICAL LABORATORY

DR. LLOYD C. FOGG

Director of the Laboratory; Assistant Professor of Zoology, University of New Hampshire

The Isles of Shoals Marine Zoological Laboratory of the University of New Hampshire is a natural outgrowth. The Isles of Shoals are a group of islands in the Gulf of Maine located about ten miles off the harbor of Portsmouth, New Hampshire. It might be more graphically described as within view of the salvaging operations of the tragic *Squalus* submarine disaster.

The Isles of Shoals have been associated with the fishing industry since the beginning of American colonization and probably before to some extent by Indians. In fact, Captain John Smith gave them the name Smith Isles. Cod, haddock, pollock, mackerel, including tuna were bountiful. Whales, porpoises, and seals were common sights. The remaining fauna constituted the typical complement of invertebrates and other vertebrates.

The Isles went through a variety of experiences from the development of an extensive trading area by diverse groups of people, to a general eviction comparable to that of Martha's Vineyard or Grand Pré, a gradual decline, then rejuvenation following the Civil War by the outgrowth of the summer hotel. In the early part of this century the hotel on Appledore Island burned leaving, however, several cottages. The cottages have been utilized for laboratory purposes.

The Marine Laboratory was founded twelve years ago by Professor C. F. Jackson of the University of New Hampshire as a summer marine station. Since that time it has gradually developed

until now facilities are available for from thirty to forty students or investigators.

The largest of the cottage type buildings is reserved for a laboratory providing a well lighted, well ventilated place for work. Other buildings include a dormitory for men, a dormitory for women, and a house for faculty, families, and guests. These buildings are located on Appledore Island which is only one of the group comprising the Isles of Shoals. None of these islands are wooded, but most of them are covered by vegetation. Rocky shores surround all of them providing numerous tide pools. Appledore has a fresh water pond. On this island there is located a Coast Guard Station as well. One island, Duck Island, is occupied entirely by a gull rookery consisting of several thousand birds. On another is a tern rookery. Although there is no extensive sandy beach or extensive mud flats, there are, off shore, both mud and rocky bottoms suitable for dredging. In brief, then, there is a flora of low vegetation above water and the typical tide level flora, fresh water pond flora and fauna, tide pools with a variety of invertebrates, a gull and a tern rookery, and all surrounded by waters containing an abundance of fish.

The facilities of the laboratory have been extended so that now students and investigators are in attendance from various parts of the country. Available to the students are now courses fulfilling

all University credits for a year's work in some one course. This year courses in Comparative Anatomy of the Vertebrates, Invertebrate Zoology, Histology-Embryology, Biology Education, and Laboratory Technique are offered. These courses are designed to meet the demand of undergraduates at inland colleges who would like to get zoology credit at a marine laboratory. Graduates now teaching avail themselves of the courses to review and refresh their zoology. The investigators work on various problems usually associated with some form found in abundance here.

The staff clearly shows a Woods Hole influence. Dr. Lloyd C. Fogg, Dr. H. J. Van Cleave, Miss Eleanor Sheehan, and Mr. George O. Lee have all spent at least a summer there. Dr. Fogg, the Director, teaches Histology-Embryology, and is carrying on cytological investigations on the cytoplasm of the malignant cell. Dr. H. J. Van Cleave, acting chairman of the Zoology Department of the University of Illinois, conducts the Invertebrate course and is pursuing his interest in parasites. With him are two investigators from Illinois who are working for advanced degrees in parasitology. Mr. Lee who teaches the Biology-Education course hails from Balboa in

the Canal Zone. The complete staff is listed in our summer announcement.

Each Wednesday evening a special lecture is given by some guest lecturer. This year we have been fortunate in having Dr. T. Hume Bissonnette from Trinity and Woods Hole and Dr. D. E. Minnich from the University of Minnesota as special lecturers. The list of speakers and topics for this summer is submitted:

DR. H. J. VAN CLEAVE, University of Illinois: Conservation of Man Meddles with Nature; MR. GEORGE O. LEE, Canal Zone, Panama: Biology of the Canal Zone; DR. T. HUME BISSONNETTE, Woods Hole, Massachusetts: Biological Effects of Light; PROF. C. F. JACKSON, University of New Hampshire: Explorations by Dog Sled; DR. D. E. MINNICH, University of Minnesota: The Mind of an Insect; DR. L. C. FOGG, University of New Hampshire: The Effects of Radiation on Cytoplasm of the Malignant Cell; and DR. F. A. KILLE, Woods Hole, Massachusetts: Experiments on Thyone.

In brief, the laboratory is located on the Isles of Shoals in the Gulf of Maine and is adapted for both undergraduate or graduate work and private investigation.

INVERTEBRATE CLASS NOTES

Coelenterates were the chief concern of the Invertebrates this week. Wednesday morning Dr. Crowell presented the case of the slighted Coelenterates and we resolved that their being ignored was not a good thing and that we certainly would do them justice. So after we were told of the differences between the gymnoblastea and the calyptoblastea and the characteristics of the hydroids of Woods Hole, we set to work drawing and describing the hydroids. By the time we had finished drawing the fifth stage in the formation of medusa in *Bougainvillia* and the twentieth tentacle on the medusa of *Obelia* as well as sketches of six other types, we felt we had been quite complete in our study of attached hydroids.

Dr. Crowell then announced that if anyone was interested in doing experiments on luminescence in hydroids a dark room was available. The next evening found us huddled about Dr. Crowell in the inky dark room watching colonies of *Obelia* give forth eerie flashes of light as they were gently stroked with the point of a dissecting pin. We thought we made a contribution to science when we found that *Campanularia* also gave forth light, but we were informed later that Dr. Harvey had discovered it years before.

The sea anemone, in the form of *Metridium dianthus*, entered our lives on Friday. We studied its physiological reactions by feeding it sand, sawdust soaked in clam juice, and pieces of putrefy-

ing clam (a tasty menu, indeed) and by prodding it until it became enraged. Our knowledge of the Anthozoa was made more complete by the observation of *Edwardsia elegans*, the inhibited inhabitant of the Mill Pond.

Saturday morning after our concluding lecture on the Ctenophores, Dr. Crowell informed us that in order that we would *have* to go swimming on Sunday, all work was due at 2. Some one suggested that "ten of four" was more appropriate. After putting in a day's work on the elusive canals of *Mnemiopsis*, some of use retired to the Eel Pond to cast stones at Ctenophores to observe luminescence and also to get revenge.

Notice was given of a Field Trip to Gansett Beach scheduled for 2:30 Sunday afternoon. Water polo was the object. The purpose of the game is to keep the ball from the members of the opposing team—no holds barred. When both teams are weary, the game is over. After an exciting game, both teams retired from the field, licking their wounds. Dr. Rankin was the star player; he got the deepest scratches, had the ball most of the time, and exhausted the most people.

We are now in the midst of the Platyhelminthes. At the close of a rapid fire lecture by Dr. Rankin, both our tongues and his are hanging out. We approach the Mess Hall with fear and trembling and the questions "How many parasites will we eat today?"

—I. Ehrmann

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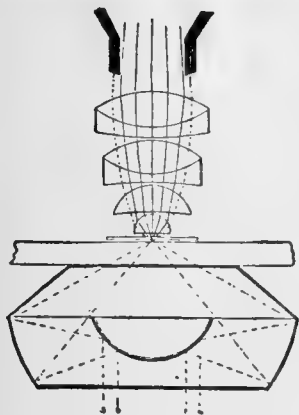
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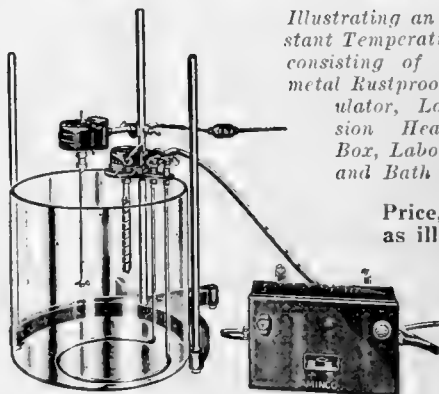
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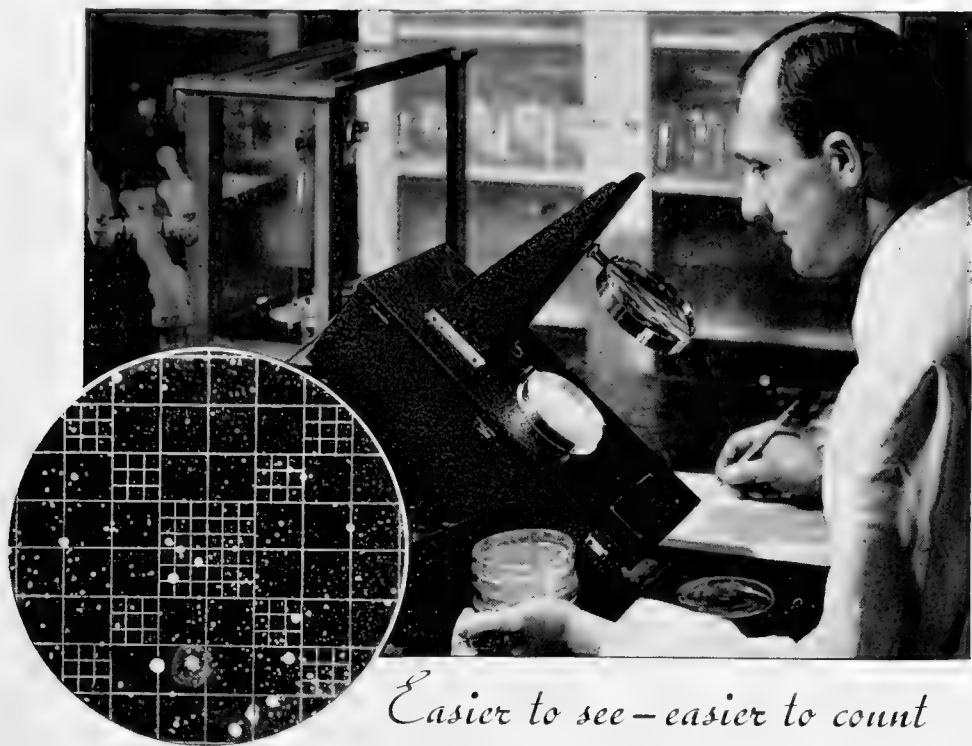
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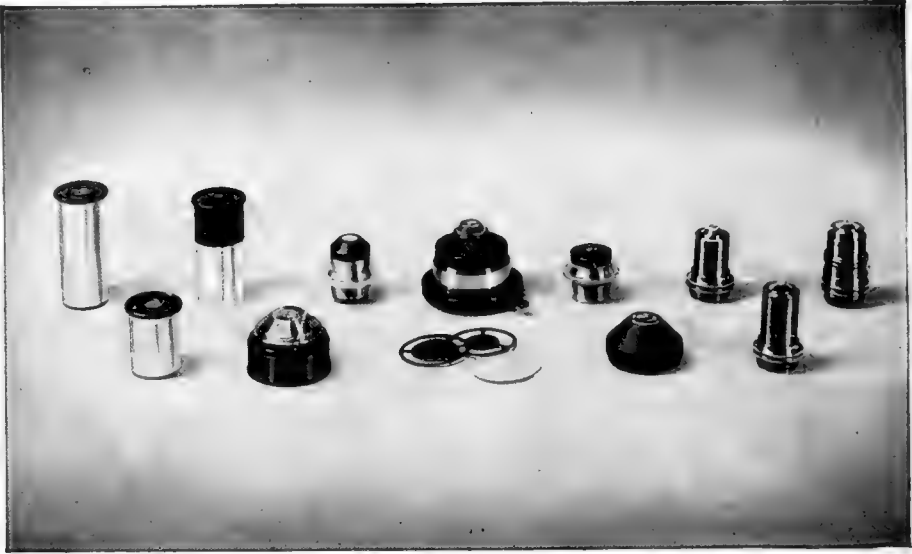
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THE COLLECTING NET

Vol. XIV, No. 7

SATURDAY, AUGUST 19, 1939

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THE OFFICIAL MEETINGS OF THE MARINE BIOLOGICAL LABORATORY

DR. CHARLES PACKARD
Associate Director

VITAMINS A AND VISION

DR. GEORGE WALD
*Instructor in Biology,
Harvard University*

The second Tuesday of August is set aside as the day when the Corporation of the Marine Biological Laboratory meets to elect eight of its members to serve as Trustees, and to hear reports on the general state of the institution. The Trustees also meet to discuss these reports, to transact necessary business, and to elect new members to the Corporation. In this brief summary I will mention various matters of interest without regard to the particular meeting at which they were discussed or acted upon.

The eight candidates for election as trustees, selected by a committee of the Corporation, were all elected without contest. Of these, seven have already served for a number of years: Drs. W. C. Allee, B. M. Duggar, L. V. Heilbrunn, Laurence Irving, W. J. V. Osterhout, A. H. Sturtevant, and L. L. Woodruff. The eighth is Dr. J. H. Northrop who replaces Prof. G. N. Calkins, now Trustee Emeritus. To fill the unexpired term of Dr. (Continued on page 145)

Most vertebrate retinas contain two groups of light receptors, the rods and cones. The rods are concerned with vision in dim light, the cones with bright light and color vision. Both end-organs transmit their excitations through a complicated chain of neurones, eventually to the thalamus and cerebral cortex.

In order to stimulate the sensation of vision probably the whole of this system must be activated, but this result is initiated by, and many of its properties limited by, the primary effects of light within the outer limbs of the rods and cones themselves.

On the most general basis this primary reaction may be formulated somewhat as follows. Some material within the outer limbs is affected directly by light, and hence may be described as photosensitive. Since it is affected by visible light, it must absorb visible light, and hence is a pigment. This photopigment is transformed by light so as to yield eventually what we may describe as a stimulating product, to

M. B. L. Calendar

MONDAY, August 21, 8:00 P. M.

Motion Pictures: Dr. R. Chambers: "Micromanipulative Studies."
Dr. C. C. Speidel: "Living Cells in Action."

TUESDAY, August 22, 8:00 P. M.

Seminar: Dr. R. M. Cable, Dr. A. V. Hunninen: "Studies on Life History of *Spelotrema hicolli*."
Dr. R. Guttman: "Stabilizing Action of Alkaline Earths upon Crab Nerve Membranes, shown in Resting Potential Measurements."
Mr. D. L. Harris: "A Study of Pigment Granules of *Arbacia* Eggs."
Dr. L. V. Heilbrunn: "Action of Calcium on Muscle Protoplasm."

FRIDAY, August 25, 8:00 P. M.

Dr. E. Sinnott: "Relation of Cells to Organs in Plant Development."

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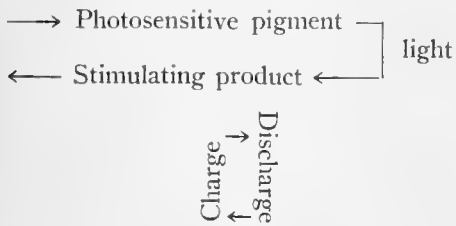
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THE TRUSTEES OF THE MARINE BIOLOGICAL LABORATORY, PHOTOGRAPHED AT THE ANNUAL MEETING ON AUGUST 9

Back row: F. P. Knowlton, E. R. Clark, H. B. Goodrich, Wm. R. Taylor, P. B. Armstrong, T. H. Morgan, R. Chambers. Middle row: C. C. Speidel, M. H. Jacobs, B. M. Duggar, Caswell Grave, W. C. Curtis, E. N. Harvey, Laurence Irving, W. R. Amberson, A. P. Mathews, L. V. Heilbrunn, Lawrason Riggs, Jr., L. L. Woodruff, G. H. Parker, R. S. Lillie, A. H. Sturtevant, J. H. Northrop. Front row: Otto Glaser, S. O. Mast, Charles Packard, G. N. Calkins, W. B. Scott, F. R. Lillie, H. C. Bumpus, E. G. Conklin, D. H. Tennent, W. E. Garrey. The following trustees attended the meeting, but do not appear in the picture: W. C. Allee, H. B. Bigelow, A. C. Redfield.

which the rhythmic, all-or-nothing discharge of the end-organ is due. The photo-pigment must be resynthesized, or vision would cease soon after irradiation had begun. The stimulating product must be rapidly removed, or vision would continue long after irradiation had ceased. It would aid the economy of the system if these latter processes were bound together, so that the system as a whole functioned cyclically without loss of material, but this, though an advantage, is not an essential general feature. This may be recognized as a generalized form of specific visual systems which Hecht has discussed for many years.



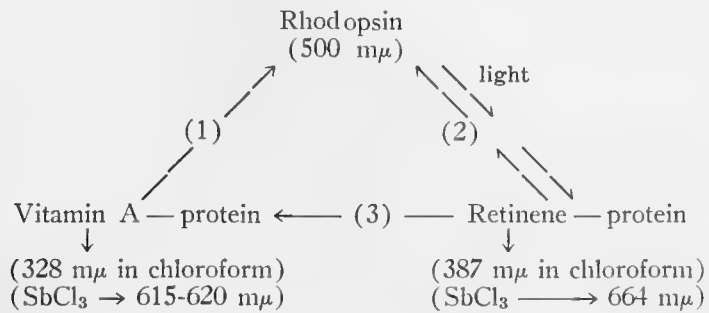
The first such photopigment was discovered in the rods of frogs by Franz Boll in 1876. It is a rose-colored substance, later called by Willy Kühne visual purple, or *rhodopsin*. Rhodopsin bleaches in the light and is resynthesized in the dark, and so fulfills the elementary requirements of a visual photopigment. In aqueous solution its absorption spectrum consists of a broad band, maximal at 500 mμ. Many of its properties show it to be a protein. But it is a conjugated protein, the special properties of which involve principally a colored prosthetic group. This is derived from the widely distributed class of yellow to red, highly unsaturated, lipoidal pigments known as the carotenoids.¹

Dark adapted retinas are rose-colored, due to their rhodopsin content. On irradiation they bleach to an orange color. In solution this reaction has been shown to consist of a succession of light and "dark"—i.e., ordinary thermal—processes, the latter accounting for at least half the total change in spectrum.² This orange product of bleaching yields all its color to neutral fat solvents. The yellow, lipoidal pigment so extracted, which I have called *retinene*, is a carotenoid. Its absorption spectrum in chloroform consists of a single broad band, maximal at 387 mμ. When mixed with antimony chloride, this substance yields the characteristic carotenoid test, a deep blue color, due in this instance to a specific absorption band at 664 mμ.

In aqueous solution retinene and protein, in part still loosely bound to each other, are the final products of bleaching. But in the isolated retina, the initial orange color fades, and within about an hour at 25°C., the tissue has become colorless. This is an ordinary thermal reaction, and occurs in darkness as well as in the light. However, in darkness there also occurs a partial reversion of the orange product to rhodopsin itself.

The extracts of completely faded retinas are colorless. They contain no retinene, but instead a large quantity of newly arisen vitamin A. This substance, C₂₀H₃₀O, possesses an absorption band at 328 mμ, and yields with antimony chloride a blue color due to a sharp band at about 620 mμ.

In the isolated retina vitamin A is the final product of bleaching. This is also the result of prolonged irradiation *in vivo*. But in the living animal replaced in darkness, vitamin A is rapidly re-synthesized to rhodopsin. The system as a whole therefore possesses the form:



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Isolation of the retina cuts the cycle at point (1); vitamin A is then the final product of bleaching. Extraction of rhodopsin into aqueous solution virtually eliminates in addition reactions (2) and (3), and leaves only the succession of light and dark processes which form retinene.^{1, 2}

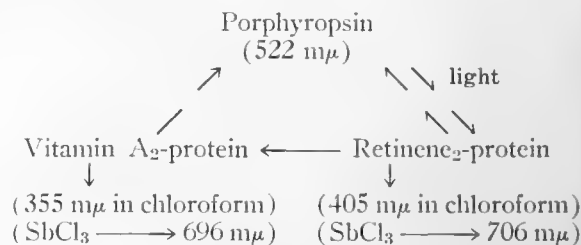
Kühne had already noted that the dark adapted retinas of fishes which he examined, unlike those of all other types of vertebrate, were distinctly purple in color. Kottgen and Abelsdorff later confirmed this difference spectrophotometrically. I have suggested that this purple photopigment be called *porphyropsin*.

For many years it has been thought that the fishes as a class possess porphyropsin. But examination of the visual systems of a number of marine fishes several years ago showed them to possess typical rhodopsin cycles.³ It has since emerged that porphyropsin is peculiarly characteristic of the freshwater fishes alone.

Porphyropsin in aqueous solution possesses the properties of a protein. Its spectrum consists of a broad absorption band, maximal at 522 m μ . On irradiation it bleaches in a succession of light and dark reactions to a russet product, the color of which is due to a carotenoid pigment. This possesses an absorption maximum in chloroform at about 405 m μ , and yields with antimony chloride a blue color due to a band at about 706 m μ . This is the final product of bleaching in solution; but in the retina it is transformed further to a new, pale yellow carotenoid, which possesses an absorption band in chloroform at 355 m μ , and yields with antimony chloride a band at 696 m μ . In the isolated retina this is the final product; but in the intact eye it in turn is re-synthesized to porphyropsin. Porphyropsin therefore participates in a retinal cycle identical in form with that of rhodopsin, but in which a 706 m μ -chromogen replaces retinene, and a 696 m μ -chromogen vitamin A.^{4, 5}

Almost simultaneously with the first publication of these observations,⁴ Lederer and Rosanova⁶ reported certain "abnormal" results obtained in the antimony chloride test with Russian fish-liver oils. While marine fishes in general yielded the familiar strong test for vitamin A, the oils from freshwater fishes tended instead to yield a dominant band at about 690 m μ . It was at once apparent that the substance which replaces vitamin A in the rods of freshwater fishes may do so also in the liver. The liver oils have provided a rich source for the further chemical investigation of this material, and this is proceeding rapidly in a number of laboratories. Since this 696 m μ -chromogen replaces vitamin A in a specific, normal physiological function, the synthesis of a rod photopigment, Edisbury *et al.* have suggested that it be called vitamin A₂.⁷ Correspondingly the retinene-analogue in freshwater fishes may be called for the present

retinene₂. The porphyropsin system may then be formulated:



Repetition with the porphyropsin system of many of the experiments originally performed with rhodopsin has demonstrated a curious relationship. In every detail the performance of the two systems, in the retina and in solution, is identical; but a constant difference in spectrum divides all components in the one cycle from their analogues in the other. The significance of this observation is now reasonably clear. Gillam *et al.*⁸ have shown that vitamin A₂ is very probably the next higher homologue of vitamin A—or A₁—possessing one added ethylenic link ($-\text{CH}=\text{CH}-$) in the polyene chain, and hence the formula C₂₂H₃₂O. Spectrophotometric studies on homologous series of natural and synthetic polyenes have shown that the introduction of such an added ethylene shifts the spectrum 20-30 m μ toward the red. The separation between the vitamin A₁ and A₂ maxima is 27 m μ , therefore in good agreement with the proposed structure. But this same range of separations holds throughout the entire rhodopsin and porphyropsin cycles. It appears, therefore, that the sole chemical difference between these two visual systems is the possession by the porphyropsin system of this added ethylene. This accounts not only for all the observed spectral displacements, but, since it should have very slight effect on the chemical properties, explains also the extraordinary parallelism in behavior of the two systems.⁵

There remains to be considered the very peculiar separation of freshwater and marine fishes on this basis. We have conducted a preliminary survey to fix the limits of the division.⁹ With a single exception mentioned below, all the marine teleost and elasmobranch species examined possess rhodopsin systems alone. All the freshwater fishes examined possess only porphyropsin systems. But the most interesting elements of this situation involve the large group of euryhaline fishes, which spawn either in fresh water (anadromous) or in the sea (catadromous), and are capable of adult existence in both environments.

The anadromous white perch possesses porphyropsin alone, though its close marine relative among the basses, the black sea bass, possesses only rhodopsin. Similarly the anadromous ale-

wife contains only porphyropsin, while its extremely close relative, the permanently marine herring, contains only rhodopsin. The anadromous brook trout, rainbow trout, and chinook salmon—all salmonids—possess mixtures of rhodopsin and porphyropsin, predominantly the latter; while the catadromous eel, which also contains both photopigments, possesses predominantly the former. The euryhaline fishes as a group, therefore, possess either predominantly or exclusively that photopigment—and hence that retinal vitamin A—ordinarily associated with the environment in which the fish is spawned.

All our evidence indicates that this pattern of retinal vitamins A is not primarily an environmental response, but is fixed genetically. Its significance is therefore to be sought in the phylogeny rather than in the physiology of the fishes.

It is commonly believed at present that all fishes originated in fresh water. The ancestral freshwater forms gave rise to modern marine fishes and to the terrestrial vertebrates, both of which possess almost exclusively vitamin A₁. The modern freshwater teleosts are believed to represent a comparatively recent re-migration from the sea; and it is with this new development that the change to a vitamin A₂ metabolism appears to be associated. If the euryhaline fishes may be considered intermediate in the migratory sense, the patterns of their visual systems agree in displaying this intermediacy, with a significant emphasis on the spawning environment. And this also is reasonable, for the spawning environment constitutes a possible permanent environment for all these animals. Passage to and from the sea is merely a potentiality, realized in varying degree by all the euryhaline fishes.

The linkage between evolutionary migration to fresh water and the assumption of vitamin A₂ metabolism appears to be well-nigh complete. Yet it is not absolute, for the tautog, of all the permanently marine fishes examined, possesses a mixture of retinal vitamins A₁ and predominantly the freshwater type, A₂.

Rhodopsin and porphyropsin are photopigments of the rods. Until very recently nothing was known directly of similar substances in the cones. It was clear that such substances must exist, and since, unlike the rod pigments, none were visible, that they must occur in very low concentrations. For this reason we chose for our first attempt to extract cone photopigments the retina of the chicken, which contains a few rods among a large predominance of cones.¹⁰ Our extracts were extremely impure, more or less by design, since we had arranged them to coax into aqueous solution as much material as possible. They were, however, photosensitive. Their bleaching in white light was characteristic neither of rhodopsin, nor

of what is expected theoretically of a cone photopigment, but about half way between. It occurred to us, therefore, that these extracts might contain a mixture of both pigments. To test this possibility we resorted to a device long familiar to workers in visual physiology. In order to stimulate cones almost to the exclusion of rods, one illuminates with deep red light, to which the rods, and rhodopsin, are comparatively insensitive.

On irradiating chicken retinal extracts with red light of wavelengths longer than 650 m μ , a peculiar type of bleaching was observed in which the absorption fell maximally in the region of 575 m μ . After this was complete, the residue was exposed to white light. A renewed bleaching occurred, maximal at about 508 m μ . The latter is characteristic of rhodopsin itself. We believe the initial bleaching in red light to be due to the photopigment of the cones. The bleaching properties of this substance show it to be a violet pigment. I have suggested therefore that it be called *iodopsin* (cf. also Chase¹¹).

A close relationship has long been recognized between the sensitivity of rod vision to the various regions of the spectrum and the absorption spectrum of rhodopsin. A similar relation is anticipated between the spectral sensitivity of cone vision and the spectrum of the cone photopigment. Honigsmann has measured the spectral sensitivity of the chicken rods and cones (*i.e.*, the dark and light adapted eyes), and has found the former to be maximally sensitive at about 520, the latter at about 580 m μ . This is the familiar Purkinje shift. The true absorption spectrum of iodopsin is still unknown. But we possess closely related functions for it and rhodopsin—the “difference spectra” obtained by subtracting from the spectra of the unbleached photopigments the spectra of their bleached products. These difference spectra are maximal at about 510 m μ for rhodopsin, and at about 575 m μ for iodopsin. The 5-10 m μ displacement of these values from the sensitivity maxima is usual in this type of comparison. The agreement is therefore very satisfactory. The Purkinje shift in chickens may be concluded to be due simply to the difference in absorption spectra of rhodopsin and iodopsin.

With the cone photopigment one encounters the problem of color vision. In man, whose color vision is based upon three primaries, it is usually assumed that the cones contain three photopigments which differ in absorption spectra. In the chicken, however, an independent basis for color differentiation exists in the tripartite system of colored oil globules. These are situated in the inner limbs of the cones at the juncture with the outer limbs, so that light must traverse them before entering the sensitive segments. They constitute three distinct groups, red, golden and

greenish yellow in color, and so form a color filter arrangement similar to that employed in many systems of color photography.

We have extracted the filter pigments of the chicken retina and fractionated them into red acidic, golden alcohol and greenish-yellow hydrocarbon portions.¹² From these we have crystallized three carotenoid pigments which simulate faithfully the colors of the retinal globules. They are the red, acidic astacene, a pigment characteristically found in crustacean shells; the golden xanthophylls, lutein and zeaxanthin, present apparently in a mixture similar to that in chicken egg yolk; and an unidentified greenish-yellow carotene, the properties of which agree with those reported for sarcinene, a pigment of the bacterium, *Sarcina lutea*.

To conclude, the vertebrates in constructing their visual systems have elaborated upon a single central theme, the carotenoid pigments. So far as now known, vertebrates can not synthesize these pigments *de novo*, however, but are limited to modifying them from carotenoids obtained in the diet, and ultimately from plants. Whenever a carotenoid is found, therefore, to fulfill some normal function in vertebrate metabolism, it does so as a vitamin; and—since the carotenoids are all closely related chemically and physiologically—as a vitamin A. Vitamin A₁ bears this relation to rod vision in most vertebrates and this explains the observation that the first observable symptom of vitamin A-deficiency in man and other mammals is night blindness. Vitamin A₂ bears this relation to the vision of freshwater fishes. If the filter pigments form the basis of color vision in the chicken retina—a possibility still to be demonstrated—then these are three color vision vitamins A. But to attempt to use the vitamin terminology with an interminable series of subscripts to

designate these substances should only produce confusion. The vitamin concept designates an important situation, both physiological and ecological, since it marks a specific interdependence among certain animals and plants. But the distribution of this situation among organisms, and of the chemical substances which sporadically participate in it, is extremely diffuse. The present problem is to understand more completely the interrelationships of the organisms for which these substances possess special nutritional significance, and the functions which they fulfill within the individual organism.

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(This article is based upon a lecture given at the Marine Biological Laboratory on August 11.)

THE EFFECTS OF LACK OF OXYGEN AND OF LOW OXYGEN TENSIONS ON SOME PROTOZOA

DR. J. A. KITCHING

Lecturer in Experimental Zoology, University of Bristol, England; Rockefeller Foundation Research Fellow, Physiological Laboratory, Princeton University

Previous work¹ on contractile vacuoles suggested that cyanide strongly inhibits the respiration of peritrich ciliates, but on the other hand it is believed that the respiration of *Paramecium*² is comparatively insensitive to cyanide. Accordingly a comparative investigation was undertaken of the effects of lack of oxygen, of low oxygen tensions, and of respiratory narcotics, on the general activities of Protozoa.

¹ Kitching, J. A. (1938) *Biol. Rev.*, 13, 403.

² Gerard, R. W. and L. H. Hyman (1931) *Amer. J. Physiol.*, 97, 524.

Protozoa suspended in a thin hanging drop were exposed to a flow of oxygen-free gas (hydrogen or nitrogen) while under microscopical observation. Hydrogen was purified over hot platinized asbestos, and nitrogen over hot copper in an internally heated furnace,³ and the purified gas was conveyed to the observation chamber by lead tubing sealed with de Khotinsky cement. Gas which had passed the observation chamber was found to extinguish completely and reversibly

³ Kendall, E. G. (1931) *Science*, N. S., 73, 394.

the luminescence of marine luminous bacteria, which are sensitive to oxygen⁴ at a tension of the order of 0.005 mm.; and a mass spectrographic analysis of the hydrogen failed to reveal any oxygen, although one part in 100,000 could have been detected. Actually the purity was probably much better than this. In some experiments known mixtures of gases were obtained by means of calibrated flow meters.

In the fresh-water peritrich *Cothurnia kellicottiana* pure hydrogen caused an almost immediate stoppage of the contractile vacuole, which was followed by a swelling of the body. Even after an hour of anoxic conditions readmission of air resulted in a rapid recovery of the contractile vacuole, and the rate of output was at first much greater than the normal. The body gradually shrank to about its normal size or less, and the contractile vacuole slowed down to its normal level of activity. The cilia also stopped beating in hydrogen and recovered in air. Complete and reversible stoppage of the contractile vacuole was obtained at 1.1 mm. partial pressure of oxygen, at 1.6 mm. the contractile vacuole stopped but recovered some slight activity after the body had swelled; and at 3 mm. of oxygen activity was normal for the period of the experiment. It may be concluded that stoppage of respiration prevented the activity of the contractile vacuole, and that the body swelled owing to the entrance of water by osmosis.

Another set of experiments was carried out on rhizopod Protozoa. In fresh-water amoebae of the "proteus" type cyanide almost immediately reduced the rate of output of the contractile vacuole to zero or thereabouts, but movement continued for several hours before the amoebae rounded up. In pure hydrogen also the contractile vacuole was soon stopped, while amoeboid movement (as already shown by Hulpieu⁵) continued for some time; the contractile vacuole recovered rapidly on admission of air. In experiments on the small marine or brackish-water amoeba *Flabellula mira* (actually cultured and used in 5 per cent sea water) all amoeboid movement and activity of the digestive vacuoles⁶ stopped within five minutes of treatment with pure hydrogen. On admission of sufficient oxygen there was a recovery both of amoeboid movement and of vacuolar activity within two or three minutes. A small measure of recovery was visible in 0.3 mm. of oxygen. This affords a valuable practical check on the speed of equilibration of the oxygen tension in a hanging drop with that of the atmosphere sur-

rounding it, since it is clear that within five minutes of contact with pure hydrogen the oxygen tension of the drop must fall below 0.3 mm. to give stoppage of movement. Equilibration may even be faster. This conclusion agrees well with theoretical deductions, for a drop $\frac{1}{4}$ to $\frac{1}{2}$ mm. thick, based on a knowledge of the diffusion constant of water.

Extensive experiments were undertaken upon *Paramecium multimicronucleatum* and *P. caudatum*. In all cases pure hydrogen or pure nitrogen led to a gradual slowing down of speed of swimming and of the rate of output of the contractile vacuoles. A limited anaerobic survival has already been claimed for *Paramecium* by various authors^{7, 8}. Finally however the organisms stopped and blistered. Recovery even after blistering had begun could be brought about by admission of oxygen. There was some recovery at a partial pressure of oxygen of 0.3 mm. The duration of anaerobic survival was very variable. Starved animals survived for less time than well-fed ones (as already shown by Pütter⁸), and animals in their own culture fluid survived much longer than did those in dilute phosphate buffer, even though in air well-fed animals appeared normal for very many hours in the dilute buffer solution. Since exposure to hydrogen or nitrogen results in a loss of carbon dioxide, with a consequent shift of hydrogen ion concentration far into the alkaline range (*e.g.* from pH 6.3 to 9.0) experiments were carried out in which the pH was kept at about 7.1 by the addition of carbon dioxide to the hydrogen or nitrogen. Slightly better survival was obtained, but the *Paramecium* died within twelve hours. The results with hydrogen and nitrogen were alike. These observations were confirmed by experiments in which *Paramecium* was kept in a tube with reduced indigo trisulphonate as indicator in the presence of hydrogen and platinized pumice. This is more satisfactory than methylene blue reduced with sodium hydrosulphite, as used by Fauré-Fremiet *et al.*⁹

It is not known what limits the activity of Protozoa at low partial pressures of oxygen. If the rate of diffusion of oxygen across the cell membrane is too slow at these low tensions, a study of the influence of temperature at low tensions might be of interest, and this is being undertaken. On the other hand, if the respiratory mechanism of the cell is unable to utilize oxygen at low tensions, it seemed that possibly (although by no means

⁷ Loeb, J. and I. Hardesty (1895) Pflügers Arch., 61, 583.

⁸ Pütter, A. (1905) Zeitschr. allg. Physiol., 5, 566.

⁹ Fauré-Fremiet, E., C. Léon, A. Mayer, and L. Plante-fol (1929) Amer. J. Physiol., 5, 633; and C. R. Soc. Biol., 101, 627.

⁴ Harvey, E. N. and T. F. Morrison (1923) J. gen. Physiol., 6, 13.

⁵ Hulpieu, H. R. (1930) J. exp. Zool., 56, 321.

⁶ Hopkins, D. L. (1938) Biodynamica no. 34, 22 pp.

necessarily) there might be some correlation between the low oxygen tensions of which the organisms can just make use, and the sensitivity of the organisms to cyanide. For instance both peritrichs and amoebae are very sensitive to cyanide, whereas *Paramecium* is relatively insensitive. It is to be presumed that amoebae and peritrichs on the one hand, and *Paramecium* on the other, rely mainly on somewhat different chains of respiratory catalysts. However, no such correlation was found, since both for *Flabellula* (an amoeba) and for *Paramecium* the oxygen tension which will

just support some visible activity is 0.3 mm.; and for *Cothurnia* (a peritrich) it is over 1 mm. The upper limit of the critical range of oxygen tensions—the limit below which respiration is no longer maximal—must be determined by respiration experiments, since visible activity might well appear maximal while respiration was not.

This work will be described in more detail, and with wider reference to the literature, elsewhere.

(This article is based upon a seminar report given at the Marine Biological Laboratory on August 8.)

THE EFFECTS OF HYDROSTATIC PRESSURE UPON CERTAIN CELLULAR PROCESSES

DR. DOUGLAS MARSLAND

Assistant Professor of Biology, Washington Square College, New York University

The capacity to undergo gelation in a reversible manner is a well recognized general property of protoplasm. Furthermore, it is generally supposed that such changes in consistency, occurring locally in a cell, may be closely related to specific physiological activities. Movement in amoeboid cells, according to the viewpoint of Mast and others, depends upon a series of gelations occurring at the anterior ends of the pseudopodia, and upon compensating processes of solation in the posterior part of the cell. Aside from this case, however, examples establishing the physiological importance of sol-gel reactions have not been clearly demonstrated.

A relationship between pressure and the structural characteristics of protoplasmic gels was first demonstrated by Dugald Brown in 1934. Brown found that the main central mass of the protoplasm of the *Arbacia* egg is relatively fluid compared to a cortical layer, about 5 microns thick, which displays the properties of a fairly rigid gel. When eggs are centrifuged at atmospheric pressure in a weak centrifugal field, the granular components of the central fluid protoplasm readily undergo displacement, but the granules of the gelled cortex, mainly the pigment granules, remain quite fixed. But when the centrifuging is done at various hydrostatic pressures up to 680 atms., a progressive liquefaction of the cortical gel is indicated. In the higher range of pressure the pigment granules are displaced with great rapidity. At 680 atmospheres the cortical gel offers less than 10% of the resistance which did obtain at 1 atm.

Since then, Brown and I have demonstrated the liquefying action of high pressure upon gel structures in a number of different kinds of cells. Similar effects have been found, in various egg cells in different stages of development, in three

types of amoeboid cells, and in plant cells in the leaf of *Elodea*. The relative magnitude of the liquefaction induced by pressure appears to be the same regardless of whether the initial gel at atmospheric pressure is quite stiff or relatively fluid. Each increment of 68 atms. (1000 lbs. per sq. in.) reduces the rigidity by about 25%. The effect is freely reversible. If the cell is returned to atmospheric pressure the original stiffness of the gelled protoplasm is regained within about a minute, or perhaps within an even shorter time.

Apparently we are dealing with a direct effect of the pressure upon protein gels, rather than with an effect upon excitable mechanisms in the cell. During the last several weeks we have found that pressure applied to an inanimate gel induces a high degree of liquefaction. With the help of Dr. Kenneth Bailey, a gel of myosin, derived from rabbit muscle, was prepared and subjected to pressures up to 540 atms. The behavior of this gel, at least in a qualitative sense, appears to be like that of the cellular gels. However, the investigation has just been started. As yet we cannot give quantitative data.

Since it has been demonstrated that pressure greatly modifies the process of gelation, it becomes of interest to investigate how such changes may be related to physiological activities in the cell. Investigations have now been made upon the movement of amoeboid cells, cleavage in egg cells and the protoplasmic streaming of the cells of the leaf of *Elodea*.

In order to see cells while under compression it was necessary to construct a special pressure chamber. The upper and lower windows are of plate glass 5 mm. thick. Light from the source is transmitted through the chamber to the objective. The objective is a special one with a magnifying power of 30 diameters, but with a working dis-

tance of 15 mm. It is used with an inverted microscope and various oculars, so that objects in the chamber may be seen at a magnification between 300 and 600 diameters.

The pressure effects upon the viscosity, or rather rigidity, of the cellular gels was measured by the centrifugal method. A centrifuge head was constructed which permits centrifugation during the period in which the cells are under compression.

First I shall rapidly outline some of the results obtained in studying amoeboid cells. When Amoebae, either *Amoeba proteus* or *Amoeba dubia*, are placed in the microscope pressure chamber at a pressure of 68 atmospheres, they assume a slightly altered form. The pseudopodia display a diminished diameter, and proportionately at least, they are longer than normal. If now the pressure is quickly raised to about 450 atms. a peculiar reaction suddenly occurs. Each of the extended pseudopodia collapses and tends to round up. This result would be expected if the plasmagel which supports the extended form of the pseudopodium were to undergo liquefaction. If the pressure is maintained for a few minutes the whole cell assumes a spherical form. When the pressure is released, however, active amoeboid movement begins again within a minute or so.

The fact that pressure does profoundly alter the physical properties of the plasmagel may be demonstrated by centrifuging experiments. When Amoebae are centrifuged while under compression the granular components of the plasmagel very quickly suffer displacement. If we take the centrifuge time necessary to induce a certain displacement of the granules as an index of the relative viscosity, or rigidity, of the plasmagel, we can plot this value in relation to pressure. It is to be noted that in the higher range of pressure, the rigidity of the plasmagel is reduced to a small fraction of its normal value. In this range no pseudopodia may be sustained. In the lower range, pseudopodia may be formed, but they display a graded diminution of diameter and length as the pressure is increased.

Comparable results have been obtained in studies of the cleaving *Arbacia* egg. When a pressure of 450 atms. is applied to eggs which have begun to furrow, the progress of the furrow is immediately arrested and gradually a recession sets in. After the pressure is released, furrowing recommences immediately and goes on to completion.

Lesser degrees of pressure merely retard the progress of the furrow. At atmospheric pressure, it requires less than 3 minutes for the furrow to pass from the equator to the axis. At 330 atms., it requires some 15 minutes. Lesser pressures

give results which fall in between these extremes. Thus it is possible to plot the rate of furrowing as a function of pressure.

Apparently a close relationship exists between the retardation of the furrow and structural changes which pressure induces in the cortical gel of the *Arbacia* egg. At the time of cleavage this gel becomes very firmly set. Centrifugal forces up to 12,000 g. are unable to exert any appreciable displacement of the pigment granules which are embedded in it. When the eggs are compressed and centrifuged, however, the pigment granules are subject to displacement.

That the retardation of the furrow is closely linked to the degree of liquefaction of the cortical gel, is shown by plotting the data in relation to pressure. Above 330 atms. no values for the rate of furrowing can be obtained, because the furrows are never completed. No values of the rigidity of the cortical gel have been obtained below 136 atms. simply because the pigment granules could not be displaced at all using the highest available centrifugal force. In the intervening range, however, the retardation of the furrow parallels the loss of rigidity of the cortical gel.

Finally, I shall just mention some similar results obtained from a study of the streaming in *Elodea* cells. As the pressure is increased the velocity of streaming gradually decreases. Complete cessation of the flow occurs at about 450 atms. At the same time, it is possible to demonstrate rigidity changes in the non-flowing part of the protoplasm which parallel the retardation of the streaming.

When two leaves are centrifuged at the same time—the one at 408 atms., the other at 1 atmosphere—the displacement of the chloroplasts of the pressure specimen is quite complete, whereas scarcely any displacement occurs in the control.

The results of this study may be plotted in relation to pressure. Again it is seen that the retardation of streaming runs parallel to the loss of rigidity of the non-flowing part of the protoplasm.

In summary, it has been demonstrated that pressure induces reversible solation, not only in various protoplasmic gels, but also in an inanimate protein gel, namely myosin. In each of the cells studied, the solation is associated with a retardation of the movement, amoeboid movement, the pinching of the cleavage furrow and the streaming of the plant cell. It appears that sol-gel reactions are providing a machine by which the cell can transform chemical potential energy into mechanical work.

(This article is based upon a seminar report given at the Marine Biological Laboratory on August 8.)

THE DIELECTRIC PROPERTIES OF INSULIN SOLUTIONS

DR. JOHN D. FERRY

Society of Fellows, Harvard University

The protein insulin, besides possessing an important specific physiological function, has a number of properties which render it an interesting substance for physical chemical study. It is one of the most stable of the globular proteins, not being readily denatured by dilute acids or non-polar solvents; and it is obtainable in highly purified crystalline form. Several investigations upon the physical chemistry of the insulin molecule are in progress at the Harvard Medical School.¹ Among these is a study of the dielectric constants of insulin solutions.

The characteristic dielectric properties of solutions of globular proteins have recently been demonstrated in a number of laboratories.² The dielectric constant of such a solution at low frequencies is generally higher than that of the pure solvent; with increasing frequency it diminishes, attaining a constant value at high frequencies which is generally lower than that of the solvent. This variation with frequency is attributed to the fact that a finite time is required for rotation of the molecules in the viscous medium which surrounds them—characterized by the "relaxation time." At low frequencies, where the period of alternation greatly exceeds the relaxation time, the molecules orient with the electric field, contributing to the dielectric constant; at high frequencies, where the relaxation time exceeds the period, the molecules cannot orient, and do not contribute to the dielectric constant.

The total drop in dielectric constant from low to high frequencies is related to the polarity of the protein molecules, and from it an estimate of the dipole moment can be made. From the frequency range in which the drop occurs, the relaxation time can be estimated, and this is related to the shape and size of the molecules. In some cases more than one relaxation time can be distinguished.

With the bridge method now in use³ measurements can be made only in solutions of low conductivity ($< 4 \times 10^{-5}$ ohm⁻¹cm⁻¹) and hence in the absence of electrolytes. In pure water, iso-electric insulin is soluble only to the extent of 0.01 g./liter¹; but propylene glycol, and propylene glycol-water mixtures can dissolve up to several grams of insulin per liter, which contributes to the

dielectric constant to a measureable extent.

Three solvents were employed in the present study, containing 100%, 90%, and 80% propylene glycol. Crystalline zinc insulin⁴ was dissolved in dilute hydrochloric acid and freed from electrolytes by electrodialysis, which caused its precipitation in amorphous form. Dielectric constants of solutions in the three solvents were measured over a range of frequencies from 6.3 to 5,000 kilocycles, at 25° C. In each case a well-defined dispersion curve for the variation of dielectric constant with frequency was obtained. From the dielectric increments per unit concentration, and the critical frequencies of the dispersion curves, estimates were made of the dipole moments and relaxation times, by formulas previously described.³ These data are summarized in Table I.

TABLE I.

Dielectric Constant Data of Insulin Solutions
(25° C.)

Solvent	Diell. Incre- ment $\Delta\epsilon/g$	Moment μ	Rel. Time $\times 10^8$ τ	Rel. Visc. η	τ/η $\times 10^8$
100% P.G.	0.25	270	84	47.5	1.8
90% P.G.	0.29	290	51	28	1.8
80% P.G.	0.38	330	27	17	1.6

There is an increase in apparent dipole moment with water content of the solvent, which may be related to the differences in dielectric constants of the pure solvents. There is also a change in relaxation time with composition of the solvent. This appears to be entirely attributable to the differences in viscosity, since the relaxation times when divided by the viscosities of the solvents relative to water (fifth column) reduce within experimental error to the same value.

The moments estimated are intermediate between the highest and lowest values previously reported for other proteins (*e.g.*, 1300 Debye units for serum pseudoglobulin,⁵ and 180 Debye units for egg albumin⁶). The relaxation time (reduced to water at 25°), 1.7×10^{-8} sec., is smaller than any previously measured. It is rather smaller than the value calculated for the rotation of a

¹ Cohn, Ferry, Livingood, and Blanchard, *Science* (in press).

² Errera, *J. chim. phys.*, 29, 577 (1932); Oneley, Ferry, and Shack, Cold Spring Harbor Symposia of Quant. Biology, 6, 21 (1938); Williams, *ibid.*, 6, 208 (1938).

³ Oneley, *J. Amer. Chem. Soc.*, 60, 1115 (1938).

⁴ Furnished through the kindness of Eli Lilly and Company.

⁵ Ferry and Oneley, *J. Amer. Chem. Soc.*, 60, 1123 (1938).

⁶ Oneley, Unpublished work.

sphere, by Stokes' Law, using the molecular volume of insulin determined by the ultracentrifuge. It is possible that the molecular weight of this protein is smaller in propylene glycol than in aqueous solution. It will be desirable to study

insulin in other electrolyte-free solvents less far removed than propylene glycol from physiological conditions—such as solutions of serum proteins.

(This article is based upon a seminar report given at the Marine Biological Laboratory on August 8.)

THE OFFICIAL MEETINGS OF THE MARINE BIOLOGICAL LABORATORY

(Continued from page 145)

C. R. Stockard who died this spring, Dr. W. R. Taylor was chosen. The duties of Secretary of the Trustees, for many years carried by Dr. Calkins, are now taken over by Dr. H. B. Goodrich. The new members of the Executive Committee are Drs. L. V. Heilbrunn and A. C. Redfield. The new members of the Corporation are Drs. H. W. Beams, John B. Buck, F. H. J. Figge, D. R. Goddard, W. J. Lynn, J. M. Oppenheimer, T. H. Ruebush, and E. W. Sinnott.

During the past year the Corporation has lost many distinguished members: Mr. C. R. Crane, President of the Trustees from 1903 to 1925, a most generous benefactor and true friend of the Laboratory; Dr. E. B. Wilson, Trustee from 1890; Dr. J. P. McMurrich, Trustee from 1892 to 1900; Dr. C. R. Stockard, Trustee from 1920; Dr. Edwin Linton, Dr. Calvin B. Bridges, Dr. H. V. Wilson, and Mr. W. O. Luscombe. Memorials of these former members were read at the Corporation meeting.

The Treasurer reported that the financial condition of the Laboratory is good, and spoke in appreciation of two gifts, one of \$20,000 from the Carnegie Corporation of New York to be used to defray the cost of hurricane repairs, and one of 500 shares of stock from Dr. F. R. Lillie.

The Librarian, Mrs. Montgomery, emphasized the fact that although the collection of bound volumes and reprints was not injured in the storm of last September, many duplicate reprints were ruined. These form an important part of the Library since they are used for replacing lost copies. She urged all members to contribute reprints, old and new, to make good the loss.

The Associate Director mentioned the increased activity in botanical investigation this summer. Three members of the Research Staff are in attendance, Dr. B. M. Duggar, Dr. D. R. Goddard, and Dr. E. W. Sinnott. The Laboratory is indebted to the Rector of the Episcopal Church, Mr. Nicholson, for placing at our disposal the greenhouse at the Rectory.

In the Report of the Committee on the Policies and Future of the Laboratory the statement is made that "it is the business of the Laboratory to help to produce investigators as well as investigation; and we believe that it can be shown that our courses of instruction have contributed in an important way to this purpose." In support of this statement may be cited some of the results of an

analysis of the scientific record of students under instruction here during the summer of 1918 to 1931 inclusive. Of the 958 men enrolled in all courses during this period 50% are mentioned in the last edition of *American Men of Science*. The percentage of women who are thus cited is considerably lower. This is to be expected since many of them marry and have no opportunity to pursue their scientific work, or they engage in secondary school teaching and have no time for research. The record is one of which we may well be proud. And while it would be wrong to assume that the large proportion has been successful because they worked here, yet we may be confident that they received at Woods Hole a stimulus which was an important factor in directing their scientific career.

In the same report it was emphasized that the Laboratory should now take steps to improve its present facilities. To this end committees have been considering the most urgent needs. It is obvious that an addition to the Library is essential for already the present space is fully utilized. In the meantime journals, reprints, and books which come in each year require a space almost equal to two stacks. Preliminary drawings for the needed addition to the building have already been prepared. Improved and enlarged facilities for the Supply Department are also needed. Dr. Jacobs and his committee are considering the question of apparatus and special facilities for carrying on experiments. While it is impossible to foresee clearly future research requirements, we should be able so to plan our present and our future buildings that new needs may be satisfactorily met. A new building of solid construction should replace the present wooden structures most of which are now fifty years old. Preliminary studies are now being made to determine how much space may be needed to house more adequately the various activities now carried on in the Old Main, Rockefeller, Botany, and the Lecture Hall. And in addition to these improvements in our material equipment, the Laboratory should seek for a substantial increase in its endowment.

All of these suggested changes are for the purpose of improving the present facilities for research and instruction. No increase in the total number of students and investigators that can be accommodated is anticipated.

The Collecting Net

A weekly publication devoted to the scientific work at marine biological laboratories.

Edited by Ware Cattell with the assistance of Boris I. Gorokhoff and Mona Garman.

Entered as second-class matter, July 11, 1935, at the U. S. Post Office at Woods Hole, Massachusetts, under the Act of March 3, 1879, and re-entered, July 23, 1938.

Introducing

MRS. FRANCESCA THIVY, Lecturer in Botany at the Women's Christian College, Madras, India; Levi Barbour Scholar at the University of Michigan.

Mrs. Thivy arrived in the United States on the S. S. *Laconia* on July 2 of this year, and immediately joined the course in Morphology and Taxonomy of the Algae at the Marine Biological Laboratory. Since the end of the course, she has been studying epiphytic algae at Woods Hole under the direction of Dr. William Randolph Taylor. She will continue to work with him on various aspects of algae at the University of Michigan during the coming academic year.

She was born in Madras, India, and studied as an undergraduate at Queen Mary's College in that city. She received a master's degree from Presidency College, having studied under Dr. M. O. P. Iyengar, a well-known ecologist in southern India.

Since 1931, Mrs. Thivy has been Lecturer in Botany at the Women's Christian College. During 1936 and 1937 one of her colleagues in the department of botany at the College was Dr. Alma Stokey of Mt. Holyoke College. In addition to her work as teacher, she has spent time at the college collecting various species of orchids indigenous to southern India.

There is a possibility that she may continue her work in the United States after her year at Michigan, depending upon whether she has completed her work at that time.

ADDITIONAL INVESTIGATORS

Finn, J. B. assoc. prof. biol. Mt. Mercy (Pittsburgh, Pa.). Rock 7. A 208.
Fraser, Doris A. res. asst. biol. Pennsylvania. OM 40. K 10.
Herriott, R. M. Rockefeller Inst. (Princeton). Br 209.
Howe, J. H. Brown. OM 21. K 14.
Rabinowitch, E. res. assoc. biol. M.I.T. Lib.
Weissenberg, R. mem. Wistar Inst. Lib.

DATES OF LEAVING OF INVESTIGATORS

Andersch, Marie August 13
Botsford, E. Frances August 9
Dumm, Mary E. August 14
Root, R. W. August 12
Russell, Alice M. August 9
Singer, M. August 13
Urie, J. C. August 14
Yntema, C. L. August 12
Zimmermann, Alice C. August 8

INFORMAL DISCUSSIONS ON THE BIOLOGICAL ACTION OF RADIATION

Radiobiological work at the Marine Biological Laboratory has one unique feature. It brings the investigators to a common meeting place in the x-ray room. The result of this has been the tendency on the part of these investigators to discuss experiments in progress and radiation problems in general.

Recently, this exchange of ideas has taken on more definite form, for various interested individuals have met as the guests of some particular individual who, as host, entertained them in his laboratory by presenting demonstrations and results of certain experiments with radiation. Three such meetings have been held thus far. The first was in the laboratory of Dr. P. S. Henshaw and the general subject dealt with was the action of x-rays on cell division in marine eggs. The second was in the laboratory of Drs. H. W. Beams and T. C. Evans. Dr. Evans presented extensive findings on the action of x-rays on respiration and development, as well as recovery from x-ray effects in the eggs of the grasshopper and *Ascaris*. The third meeting was held last Monday evening in the Board Room where Dr. G. Failla presented a theory on the biological action of radiation which he has recently propounded.

In all three cases, discussion and questioning occupied a good bit more time than the actual presentation of material. Thus, the persons who acted as hosts were able to profit by leading questions, suggestions and criticisms, and the guests obtained interesting first hand information—in some cases directly through the microscope. It is expected that other such meetings will be held.

CURRENTS IN THE HOLE

At the following hours (Daylight Saving Time) the current in the Hole turns to run from Buzzards Bay to Vineyard Sound:

Date	A. M.	P. M.
August 19	8:02	8:35
August 20	8:54	9:30
August 21	9:51	10:25
August 22	10:46	11:30
August 23	11:48	.....
August 24	12:34	12:45
August 25	1:37	1:48
August 26	2:26	2:41
August 27	3:18	3:24
August 28	3:59	4:07

In each case the current changes approximately six hours later and runs from the Sound to the Bay.

ITEMS OF INTEREST

COLUMBUS O'D. ISELIN, assistant professor of oceanography at Harvard University, was appointed director of the Woods Hole Oceanographic Institution at the annual meeting of its Board of Trustees last week. He succeeds Dr. Henry B. Bigelow, who was elected president of the Corporation replacing Dr. F. R. Lillie.

DR. J. D. BERNAL of Birkbeck College, England, and DR. JOSEPH NEEDHAM, professor of biochemistry at Cambridge University, have arrived in Woods Hole. They had attended the *Growth* Symposium at North Truro. Dr. Bernal delivered a lecture at the Marine Biological Laboratory on "The Biological Significance of Protein Structure" on Thursday, and Dr. Needham gave a lecture the following evening entitled, "The Metabolism of the Gastrula, with Reference to the Amphibian Primary Organiser." Both Dr. Bernal and Dr. Needham spoke at the open meeting of the American Association of Scientific Workers on Wednesday. Dr. Needham will speak at the Penzance forum tomorrow afternoon on "A Revaluation of the Idea of Progress."

DR. JOSEPH VICTOR has been made full professor of pathology at Columbia University. He was at the Marine Biological Laboratory in 1934.

DR. R. K. MEYER has been promoted from assistant professor to professor of zoology at the University of Wisconsin. Dr. Meyer was at the Marine Biological Laboratory in 1930.

DR. WILLIAM C. YOUNG, assistant professor of biology at Brown University, has been appointed associate professor of primate biology at the Yale University School of Medicine. He will work on chimpanzees at the Laboratories of Primate Biology, Orange Park, Fla., and at New Haven. Dr. Young has come to Woods Hole to work for the second half of the summer.

DR. RICHARD THOMPSON has been promoted from assistant to associate professor of bacteriology at Columbia University.

DR. IVON R. TAYLOR, assistant professor of biology at Brown University, has been appointed associate professor.

DR. CARL LEONARD LARSON, M.D., has been appointed assistant professor of bacteriology at George Washington University.

DR. JOHN E. DAVIS, former instructor in pharmacology in the School of Medicine of the University of Alabama, has been appointed instructor in pharmacology and biochemistry at the University of Vermont Medical School.

PROFESSOR C. G. ROSSBY, formerly professor of meteorology at the Massachusetts Institute of Technology, and now assistant chief of the United States Weather Bureau, is visiting Woods Hole with a group of several men interested in meteorology. They have come to hold conferences with Dr. V. Ekman and other members of the Woods Hole Oceanographic Institution.

ADMIRAL L. O. COLBERT, director of the U. S. Coast and Geodetic Survey, completed a week's visit to Woods Hole on Wednesday.

PROF. B. P. BABKIN, research professor of physiology at McGill University, is arriving today in Woods Hole and will spend the remainder of the summer here. He will be accompanied by his wife and daughter.

DR. MARIE A. HENRICHIS, who first came to the laboratory in 1916 and worked at the laboratory for thirteen years, arrived in Woods Hole on Monday and will be visiting here for a week or more. Dr. Henrichis is now professor and head of the Department of Physiology and the Student Health Service at Southern Illinois State Normal University at Carbondale, Illinois.

DR. C. E. HADLEY, associate professor of biology at the Montclair State Teachers' College, New Jersey, arrived in Woods Hole this week. Last year he was on the instruction staff of the invertebrate course at the Marine Biological Laboratory.

DR. C. S. LEONARD, assistant professor of pharmacology at the University of Vermont Medical School, visited at Woods Hole for several days this week.

MRS. ELIZABETH C. CALLISON, associate physiologist at the Bureau of Home Economics, United States Department of Agriculture, who took the Physiology course in 1920, has been visiting Woods Hole this week.

MISS HAZEL GOODALE, who is the daughter of Dr. H. D. Goodale, the geneticist, and who was a member of the staff of THE COLLECTING NET last summer, returned on Tuesday to Williamstown, Mass., after a visit of ten days at Woods Hole.

M. B. L. CLUB

The trimming of the exterior of the M.B.L. Club House was repainted in green this week.

Mrs. Marshall Smith is the new chairman of the house committee, replacing Mrs. M. W. Bosworth, who is leaving Woods Hole this weekend.

An informal song-fest was held at the Club House on Thursday night; many students and investigators took part.

ITEMS OF INTEREST

Delegates to represent the United States at the Seventh International Congress of Genetics at Edinburgh from August 23 to 30 have been appointed as follows: Dr. Hugh C. McPhee, of the United States Department of Agriculture, Chairman; Dr. Albert F. Blakeslee, of the Carnegie Institution, Cold Spring Harbor, New York; Dr. Lewis J. Stadler, of the University of Missouri, and Dr. Sewall Wright, of the University of Chicago.

DR. HENRY B. BIGELOW, former director of the Woods Hole Oceanographic Institution, assisted in presiding at a conference held at Washington on July 23 under the auspices of the National Academy of Sciences and the National Research Council concerning scientific arrangements for the forthcoming Antarctic Expedition under the direction of Admiral Richard E. Byrd.

On Wednesday, August 16, Dr. V. W. Ekman delivered a lecture in the lounge of the Woods Hole Oceanographic Institution on "Some Experiences and Researches about the Structure of Ocean Currents." This lecture was continued on Friday evening. At the Woods Hole Oceanographic staff meeting on Thursday he spoke on "Principles of Dynamic Oceanography."

The Ninth Convention of the Biological Photographic Association will meet Sept. 14 to 16 in Pittsburgh. Meetings will be at the Mellon Institute.

DR. RHEINHARDT DOHRN, director of the Naples Zoological Station, reports a very active spring session at the laboratory this year. One outstanding result was the isolation of fertilizin (F. R. Lillie) from sea urchin eggs by Dr. Max Hartmann and collaborators.

M. B. L. TENNIS CLUB

Characterized by some excellent matches and appreciative galleries, the annual tennis tournament of the M.B.L. Tennis Club has been progressing toward the final rounds, which will be played in the doubles events this week-end. Finalists in the singles tournaments will meet next week-end.

A close match is expected in the men's doubles when Lancefield and Krahl meet Patton and Ruebush. The former team gained the finals by defeating Schmidt and Katzin 7-5, 6-3 in a semi-final match. In the other semi-final, Patton and Ruebush downed Speidel and Ball in a close battle, 6-2, 9-7. The victors had set point against them seven times in the exciting second set but each time were able to hold off their opponents.

Play for the Strong Cup in the mixed doubles has brought Ruebush and Musser to the finals, with the other bracket to be filled by the winner of the semi-final match between Dr. and Mrs. Lancefield and Dr. Krahl and Mrs. Clowes. Results of play in the six tournaments to date are as follows:

Men's Singles: First round—Ruebush defeated Schmidt, 6-2, 6-0; Spinnler d. Jones, 6-3, 3-6, 6-1; Mavor d. Rugh, (default); Herriott d. Kidder, 6-1, 4-6, 6-3; Wickendon d. Bolster, 6-1, 6-4; Williams d. Katzin, 6-1, 6-2; Kaylor d. Carpenter, 6-3, 6-3; Minden d. Buck, (default). Second round—Kaylor d. Minden, 6-0, 6-0; Ruebush d. Spinnler, 6-1, 6-2.

Women's Singles: First round—Musser d. Schmidt, 6-3, 6-4; Hamilton d. Fowler, 7-5, 6-2; Highet d. Morgan, 6-2, 6-0; Alley d. Katzin, 6-4, 2-6, 6-4; Borden d. Hansen, 6-4, 6-0; Jones d.

Henshaw, 10-8, 6-4; Ramsdell d. Safford, 6-4, 6-1; Brown d. White (default). Second round—Musser d. Hamilton, 6-3, 6-2; Ramsdell d. Brown, 6-1, 6-0.

Junior Singles: First round—Mavor d. Koller, 6-2, 6-4; Graham d. Bigelow, 6-2, 3-6, 6-4; Leonard d. Garlock, 6-4, 6-0; Saunders d. Goodwin, 6-2, 6-4.

Men's Doubles: First round—Schmidt-Katzin d. Mavor-Mavor, 6-1, 6-3; Frew-Spinnler d. Jones-Carpenter, 6-0, 6-3; Speidel-Ball d. Muse-Hume, 6-0, 6-0; all other teams drew byes. Second round—Krahl-Lancefield d. Bolster-Williams, 6-4, 6-0; Schmidt-Katzin d. Kidder-Herriott, 6-4, 1-6, 7-5; Patton-Ruebush d. Frew-Spinnler, 6-4, 7-5; Speidel-Ball d. Duryee-Wickendon, 0-6, 6-2, 6-3. Semi-final round—Krahl-Lancefield d. Schmidt-Katzin, 7-5, 6-3; Patton-Ruebush d. Speidel-Ball, 6-2, 9-7.

Women's Doubles: Highet-Norman d. Katzin-Fowler, 6-0, 6-0; Voter-Poole d. Alley-Safford, 6-3, 6-4; TeWinkel-Jones and Brown-Henshaw, byes. Second round—TeWinkel-Jones d. Brown-Henshaw, 6-2, 6-3.

Mixed Doubles: Krahl-Clowes d. Hume-Poole, 3-6, 6-3, 6-1; Jones-Jones d. Carpenter-Carpenter, 6-2, 6-3; Ruebush-Musser d. Kidder-TeWinkel, 6-2, 6-1; all other teams drew byes. Second round—Lancefield-Lancefield d. Algire-Hamilton, 6-2, 6-3; Krahl-Clowes d. Jones-Jones, 6-1, 6-1; Ruebush-Musser d. Katzin-Katzin, 6-1, 6-1; Wickendon-Kindred d. Spinnler-Voter, 6-3, 6-1. Semi-final round—Ruebush-Musser d. Wickendon-Kindred, 6-1, 6-1.

INVERTEBRATE CLASS NOTES

"Parasites are organisms which have lost most of their organs and all of their self respect," so spoke Dr. Rankin as he summarized the characteristics of the Trematodes and Cestodes—and we began our second day with the Platyhelminthes. Our prize opus was the life of *Cryptocotyle lingua* from redia to adult, even to the watching of encystment of cercaria in *Fundulus* fin.

The field trip to Lagoon Pond Bridge was outstanding in that we met our ancestors, from the evolutionary standpoint,—the Urochordates—in the form of *Amaroncium*, *Botryllus*, *Perophora*, and *Didemnum* all living happily together on the pilings. Marzulli, under his five days' growth of beard, willingly posed as the link between the Protochordata and the Vertebrata and our picture was complete.

Our weekend was spent in classifying forty-odd annelids for Dr. Lucas, though we took time out Sunday to listen to the concert on Georgia's portable radio.

The collecting crew presented us with a Portuguese Man-of-War, which is living happily in our midst—alternately feasting and fasting, depending upon the supply of *Fundulus*.

As the fog rolled away Tuesday morning, we boarded the *Winifred* and the *Caprice* for the fer-

tile flats of Cuttyhunk. Upon arriving at our destination, we spent the remainder of the morning trying to remove specimens as well as ourselves from the muddy ooze that has settled in the cove by the dock since the historical hurricane of '38. The lunch whistle was greeted by enthusiastic shouts of "Food," "We eat," and "Out of my way."

We set out again after lunch with our arks practically empty, for the morning's pickings were poor. We spent part of the afternoon in the tide pools and on the beach of *bona fide* Atlantic Ocean. We soon discovered for ourselves that ocean swept regions were not very fertile—though we met our first serpent star there. We proceeded to the channel and really began to find things—Arbacia was *the* specimen of the afternoon.

Things to remember: Dr. Rankin's climbing of the mast of the *Winifred*; Dr. Matthews singing of "Roamin' in the' gloamin'"; the orchestra on the *Winifred*—flute, ocarina, harmonica, and uke; Team One's *Cerebratulus*, Team Three's collection of *Henricia* and *Arbacia*, Team Two's 102 "rare" specimens. And there's a story of the girl who searched the shore for sand dollars and found a nickel instead.

—Irene Ehrmann

AMERICAN ASSOCIATION OF SCIENTIFIC WORKERS SPONSORS MEETING

An open meeting sponsored by the American Association of Scientific Workers was held at the Marine Biological Laboratory last Wednesday evening. The title announced was "The Social Functions of Science;" Prof. G. H. Parker served as chairman and introduced the three speakers for the evening.

Dr. J. D. Bernal of Birkbeck College, England, opened the discussion by outlining the responsibilities of scientists. He declared that science is dependent upon practical, commercial applications for its existence, despite the general view that pure science is the aim of research and that economic motives are very secondary. He quoted statistics to show that the greater part of scientific research is conducted for military, industrial and agricultural purposes, and that only an infinitesimal part of the national income is devoted to pure science. From these facts, Dr. Bernal concluded that science was inseparably connected with the general welfare. He then took up the question of what the attitude of science should be towards society. Specifically he mentioned the need for improving nourishment, for guarding the interests of science, for establishing research as a profes-

sion, and for bringing order into the "chaos" of scientific publications.

Dr. Joseph Needham of Cambridge described how an attempt had been made in England towards translating these general obligations into action through the formation of the English Association of Scientific Workers. He discussed its organization, personnel, and activities which included deciding disputed cases in relation to individuals, applying legislative pressure to the government, criticising government reports, and organizing scientific workers to aid in case of war.

Dr. George Wald of Harvard, as a "rank and file member" of the American Association of Scientific Workers, described its organization and history. It was started a little more than a year ago by a group of Philadelphia scientists, and now has four branches and a membership of 400. It has no trade union connections. While its activities so far have been primarily organizational, it has already established committees to deal with such topics as legislation, socialized medicine, and public relations.

Opportunity to join the American Association of Scientific Workers was offered at the conclusion of the meeting.

—B. I. G.

BOOK REVIEW

CRYSTALLINE ENZYMES. The Chemistry of Pepsin, Trypsin, and Bacteriophage. By John H. Northrop. Columbia University Press. \$3.00. xv + 176 pp. (including 35 tables) + 45 illustrations. 1939.

Contents: Preface; 1. General Chemistry of Enzymes; 2. Pepsin; 3. Pepsinogen; 4. Chymo-trypsinogen and Chymo-trypsin; 5. Trypsinogen, Trypsin, and Trypsin-inhibitor; 6. Carboxypeptidase; 7. Bacteriophage. Appendix: Preparation and Crystallization of the Enzymes. Literature. Index.

"One of the most striking characteristics of living things is the rapidity and precision with which chemical changes necessary for their existence are carried on." The above quotation is the opening statement in a monograph which must be marked as one of the outstanding contributions to the literature on enzymes and proteins. This monograph is not a review of all crystalline enzymes. It is a summary of the work done in Northrop's laboratory at The Rockefeller Institute for Medical Research (Princeton, N. J.). Northrop and his collaborators have shown that the catalytic activity of some proteolytic enzymes is a peculiar property of certain protein molecules. Purification and subsequent crystallization of these proteins have permitted careful analyses of the conditions under which these enzymes are active.

Knowledge of such systems as found in trypsinogen-trypsin conversions, for example, are stimulating to biological thinking. These systems involve inactive precursors (protein molecules) which may be autocatalyzed by active enzymes (also protein molecules) to produce more of the same active enzyme. The general reaction may be stated as follows:



The kinetics of such reactions obey simple autocatalytic laws except where the presence of inhibi-

tors may modify the rates of transformation. In the pepsinogen and trypsinogen systems, inhibitors have been isolated and were found to be low molecular weight polypeptides.

Most of the enzymes which occur in living systems may be considered as substances which have evolved with the organism and are maintained during the life of that organism. There are, however, "parasitic macromolecules" (viruses and bacteriophages) which some organisms acquire and maintain but usually to the disadvantage of the host. Although Northrop does not discuss viruses in general, the bacteriophage may be considered as a virus which acts on bacteria. Furthermore, Northrop has shown that the Bacteria Phage

→ Phage reaction is autocatalytic. The inactive precursor is apparently present in the protoplasm of bacteria, and if an autocatalyst (phage) is added, more of the active molecules (phage) are produced. The results of Northrop's work on enzyme systems enable one to understand the very high degree of host specificity which viruses and phages exhibit. For example, it may be assumed that highly susceptible protoplasm contains the inactive precursor, while non-susceptible protoplasm lacks this substance. In the latter case no effect is produced by introducing an autocatalyst since the necessary substrate is absent. Viruses and phages are examples of some of the most precise host-parasite relationships.

A very valuable feature of this monograph is the appendix. In it are summarized exact procedures for isolating, purifying and crystallizing not only the proteolytic enzymes, but also for the purification of the phage. Such procedures, in all probability, may be profitably used on other proteins.

This monograph is the 12th volume of the Columbia Biological Series. —M. J. K.

NERVE ASPHYXIATION IN RELATION TO TEMPERATURE

DR. HERBERT SHAPIRO

Research Associate in Physiology, Clark University

The metabolic changes occurring in nerve accompanying the passage of an impulse are so minute that it has been only since approximately 1926 that nerve heat has been successfully measured. At that time A. V. Hill observed, "it is not to be wondered at that a nerve is relatively infatigable. Another and an even more vivid way of describing the smallness of the energy exchanges lies in the statement that about as much heat is liberated in a nerve by the passage of half a million impulses, as in muscle by a single twitch." The interesting question thus arises, as to whether any of the phases of nerve activity are purely physical manifestations, or whether some of them are mediated through chemical reactions. In certain electrophysiological phenomena, such as brain

waves, much of the evidence points to a chemical basis. For example, the "alpha" frequencies may be affected by substances which in other tissues alter metabolic rates, thus indicating that these frequencies are an expression of cortical metabolism. By diathermy treatment, Hoagland has demonstrated that the frequency of human alpha brain waves is a function of temperature and obeys the Arrhenius equation

$$v = z \exp - \mu/RT$$

where v represents the velocity of the chemical reaction at temperature T , and μ is the energy of activation, or "temperature characteristic" as it is

frequently called when applied to biological processes, when one is not certain of its identification with an energy of activation. R and z are constants. Normals and early general paretics show a μ value for the alpha frequency of brain waves of about 8,000 calories, intermediately advanced paretics about 11,000 calories, advanced paretics about 16,000 calories. These are values frequently found in *in vitro* studies of oxygen uptake, and may correspond to energies of activation of enzyme systems, where the slowest link in the chain acts as the pacemaker and determines the μ value, if frequency is a function of respiratory rate.

Hadidian and Hoagland have prepared a succino-dehydrogenase, cytochrome-cytochrome oxidase system from beef heart, which oxidizes succinate to fumarate. By examining this reaction (through measurement of oxygen uptake) as a function of temperature, it was shown that addition of cyanide (to poison the cytochrome oxidase, and thus make it the slow link) yielded a μ value of 16,000, whereas when the succino-dehydrogenase was made the slow link, by selective poisoning, the μ value which emerged was 11,200. Thus 16,000 calories appears to be the activation energy of cytochrome oxidase, and 11,200 that of succino-dehydrogenase.

When a nerve is kept in pure nitrogen or hydrogen, as in the experiments reported here, it continues, despite the absence of oxygen, to conduct the nerve impulse, though not indefinitely. By placing the nerve in a suitably constructed all-glass chamber, containing platinum electrodes for stimulating, and calomel electrodes for recording, and immersing the chamber in a Dewar flask, the entire contents may be kept at constant temperature for many hours. To test for the production of action currents, a short tetanus is applied at regular intervals, and the action current lead off through the calomel electrodes is integrated by a sensitive ballistic galvanometer, and so a measure of the total action current produced is obtained. During asphyxiation, the total action current obtainable from the standard stimulus falls steadily and finally disappears. The after positivity is much more labile than the action current, and always precedes it in dropping out of the picture during oxygen lack. The injury potential also falls, but not to zero. The sciatic trunk of the Hungarian bull-frog, *R. esculenta*, requires about 1150 minutes at 0°C. before it fails, whereas at 38°C. it will asphyxiate in about an hour. Asphyxiation time is thus an exponential function of temperature, and when plotted on the semi-log grid is found to obey the Arrhenius equation with a μ value of 11,100 calories. If a nerve is tetanized continuously in nitrogen, the asphyxiation time is shortened. It is of interest in this connection that nerve tetanization during anoxia acceler-

ates the decomposition of creatin phosphate (Gerard and Tupikova).

Upon admission of oxygen, all of the electrical properties of nerve here studied, action current, after positivity, and injury potential, show a recovery. The rate of recovery of the action current is again found to be an exponential function of temperature, with a μ value of 28,000 calories.

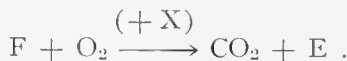
Gerard has postulated three different chemical reactions underlying conduction, refractory period and recovery in nerve. They are (1) the breakdown of creatin phosphate during conduction, to yield decomposition products, including an X substance which accelerates later reactions,



(2) a resynthesis of creatin phosphate during the refractory period through energy yielded by accessory reactions



and finally (3) during recovery, CO_2 , and energy result from certain oxidations



Taking Amberson's data on the effect of temperature on the absolute refractory period, we find again a conformation to the Arrhenius equation with a μ value of 18,400.

The data as a whole lead to the supposition that during anoxia, the nerve turns to the utilization of certain anaerobic energy yielding reactions exclusively, for setting up and conducting nerve impulses, that these reactions, in common with other chemical reactions, proceed at a rate dependent upon temperature, but that their completion may be accelerated by tapping off energy through continuous tetanization. Readmission of oxygen permits a reversal of certain of these reactions through side reactions yielding energy for resynthesis. The equations postulated, would from their nature, very likely involve different enzyme systems and hence three different μ values representing essentially different chemical reactions are to be expected, though the μ values alone do not permit an explicit statement of the components of the chemical reactions. This is what has been found in these experiments for loss of conduction, for aerobic recovery, and from the available data for the absolute refractory period, in amphibian nerve.

(This article is based upon a seminar report given at the Marine Biological Laboratory, August 8. The work was made possible through a grant from the John Simon Guggenheim Memorial Foundation.)

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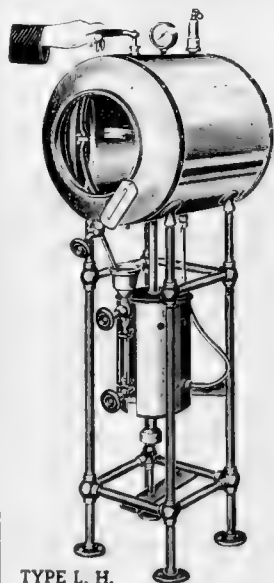
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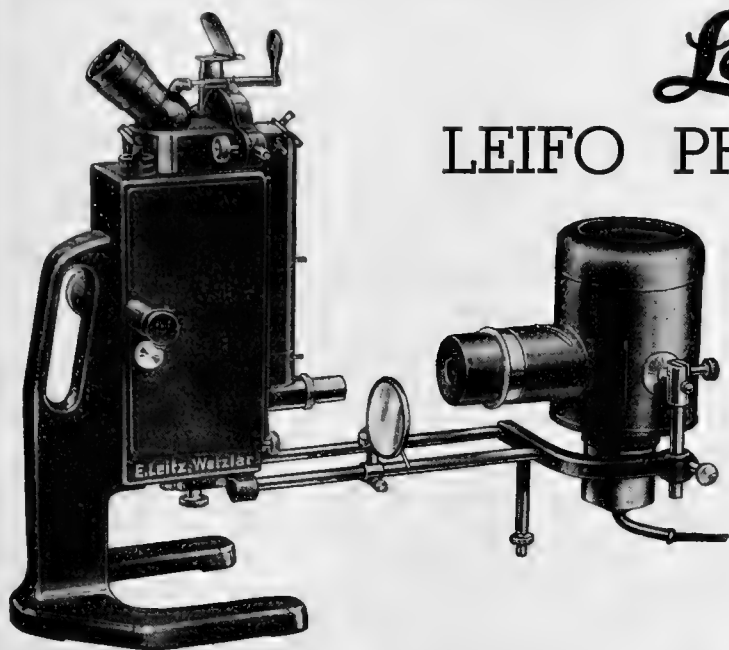
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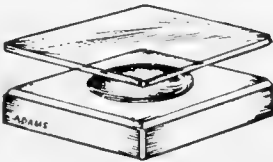
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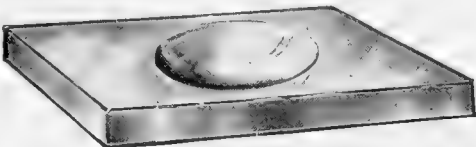
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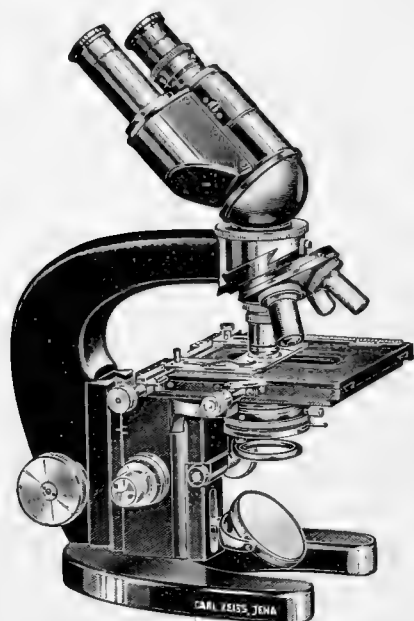
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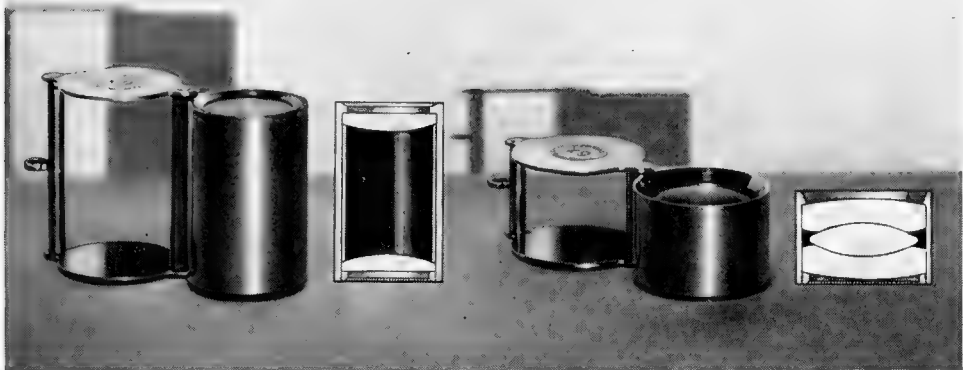
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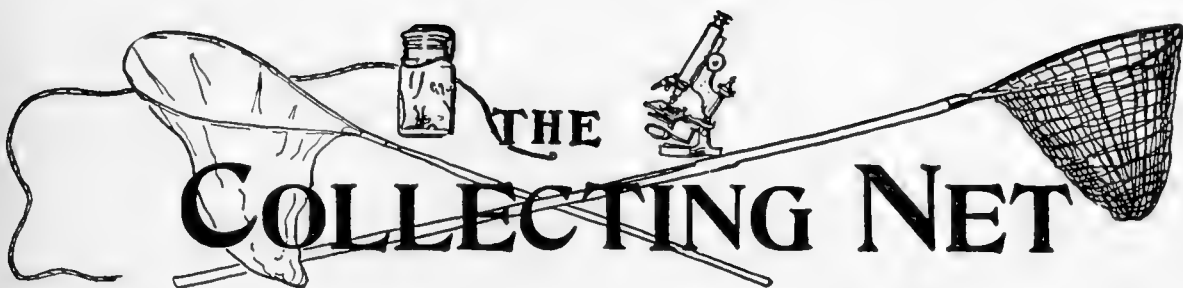
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EXPERIMENTS ON THE PRODUCTION OF HAPLOID SALAMANDER LARVAE

DR. CORNELIUS T. KAYLOR

*Instructor in Anatomy,
College of Medicine, Syracuse University*

It has been known for some time that the eggs of many species of amphibians can quite easily be induced to begin their development with either the male or the female set of chromosomes. This would then produce haploid embryos and larvae.

In spite of the large number of experiments which have been performed on the production of haploid amphibians, (see review of Fankhauser, J. Hered., 28, 1937), the results have varied with the species of eggs used, with the methods used, with the degree of abnormality of the embryos produced, and with the extent of development. So far as has been demonstrated, only one completely haploid larva has been reared to a stage approaching sexual maturity (Baltzer & Fankhauser, 1922). The non-viability of all these experimentally produced haploid animals is in striking contrast to the fact that haploid animals occur in nature (Continued on page 175)

BIOCHEMICAL ASPECTS OF EXPERIMENTAL MORPHOLOGY

DR. JOSEPH NEEDHAM

*Sir W. Dunn Reader in Biochemistry,
University of Cambridge, England*

There are three ways in which the great problem of the relation between morphology and biochemistry can be approached. In the first place we may make a direct attack upon that vague region between the largest chemical particles and the smallest morphological structures which we know. In this realm come the study of paracrystalline aggregates, colloidal micelles, fibrous macromolecules, protein structure, etc. We had the advantage of listening to an interesting exposition on some of these questions by Dr. J. D. Bernal the other night.

The second way in which we may attempt to bridge the gulf between morphology and biochemistry is by studying the chemical changes which go on during embryonic development, a time at which the morphological change is the most ob-

vious variable.

Up to 1931 this was perhaps the only contact between biochemistry and embryology, but since

M. B. E. Calendar

TUESDAY, August 29, 9:00 A. M.

General Scientific Meeting.

TUESDAY, August 29, 2:00 P. M.

General Scientific Meeting (cont.)

WEDNESDAY, Aug. 30, 9:00 A.M.

General Scientific Meeting (concl.)

THURSDAY, August 31, 8:00 P.M.

Motion Pictures and Lecture: "Congo Color," motion pictures of the McGill Congo Expedition; Mr. Frank L. Hodgson.

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Photo by Fred S. Howard

STAFF AND STUDENTS OF THE INVERTEBRATE COURSE AT THE MARINE BIOLOGICAL LABORATORY, 1939.

Back row, standing: L. M. Bartlett, M. K. Winborn, Dr. J. S. Rankin, Jr., Pauline A. Ramsdell, Anne Kidder, Barbara C. Allen, Lucy F. Williams, Catherine H. Fales, M. E. McDonald, R. W. Harrison, Frances H. Schneidermann, Sylvia R. Frank, Kathryn L. Roller, Sarah D. Browne, Vivian Sweibel, Jeannette L. Mandrey.

Middle row, standing: Catherine D. Hemphill, P. L. Douglas, C. M. Williams, Gertrude Christiansen, Mary N. Hall, Mary D. Rogick, R. L. Terry, E. D. Bueker, G. G. Robertson, G. G. Lower, Rebecca DuBois, Elizabeth Day, R. E. Tonks, F. W. Ludwig, J. C. Cavender.

Front row, standing: Gladys M. Chambers, Evelyn J. Hall, R. E. Leninger, Alvin A. Winsten, Muriel A. Voter, Lucille D. Jenkins, B. Elizabeth Zabelin, R. W. Egan, Ruth Rayburn, Frances L. Spence, R. L. Bacon, G. W. Molnar, J. D. Ifft, E. W. Opton.

Back row, seated: Dr. N. T. Mattox, Dr. F. R. Kille, Dr. A. M. Lucas, Dr. T. H. Bissonnette, Dr. P. S. Crowell, Jr., Dr. W. E. Martin, Dr. A. J. Waterman, Dr. J. C. Wightman.

Front row, seated: J. H. Kincaid, F. Bradley, A. J. Samorodin, C. Metz, Madelon R. Grimm, P. J. Bilka, F. N. Marzulli, T. J. Walker, E. L. Powers, Jr., Frances L. McCalla, Irene Ehrmann.

that time a third method of approach has become possible, *i.e.*, the biochemical investigation of what we may call the morphogenetic hormones.

For more than half a century, it has been known that regions of the embryo exert upon one another during their development important formative influences. Such effects were described by W. Roux as dependent differentiation, in order to distinguish them from self-differentiation, in which a tissue will go forward independently, appearing to possess within itself all its marching orders.

The first instance to be studied of the effect of one organ upon another in embryonic development was that of the induction of the lens by the eye-cup, found by Spemann and Warren Lewis simultaneously about the beginning of the present century, but this induction has not so far lent itself very well to biochemical analysis, although in the work of Lopaschov and others this is now beginning. On the other hand, considerable progress has been made in the study of the primary inductor of the amphibian embryo from this angle.

When the presumptive notochord and mesoderm invaginates during gastrulation in the amphibian embryo, it comes to lie under the presumptive neural plate. We know now from the work of Spemann and his colleagues that the invaginated material stimulates the overlying tissue, forming thus the neural plate, the neural tube, and hence the main neural axis of the vertebrate organization-plan. At the same time the fate of the presumptive neural tissue is sealed, so that it can no longer be altered, and as it is formed in this way it itself acquires the capacity of inducing another neural plate if it is transplanted into another embryo (homoio-genetic induction). The dorsal lip of the blastopore, through which the invagination goes on, is called the organization center, or organizer, because, if transplanted into another embryo, it will organize the tissues which surround it into a secondary neural axis. Both in normal development and in the induced development of such a Siamese twin, the action of subsequent organizers (*i.e.*, the eye inductor for the lens, mentioned above) will follow later upon the primary induction.

The beginning of the biochemical approach may be dated from 1931, in which year it was shown that the activity of the organizer center is retained after the crushing of the cells. It was speedily found that boiling the organizer center does not destroy its activity and this led to a series of researches in which the primary inductor activity of

many different substances, whether likely to be contained in the gastrula itself or not, was tested. While the Cambridge group obtained the best results from the unsaponifiable fraction of the ether extract of neurulae, the Freiburg group found that higher fatty acids, nucleoprotein preparations and adenylic acid were also active. These workers further discovered that crude glycogen preparations possess activity (Fischer & Wehmeier). But in Cambridge it was possible to demonstrate that this activity is due to the presence of small quantities of ether-soluble material attached, and removable from, the glycogen preparation. It is doubtful, however, whether the presence of minute amounts of ether-soluble material will explain the activity of all the chemical substances which have been found to be effective—such, for example, as the kephalin from mammalian brain (Barth).

As it turned out, there is a very definite reason for the apparent lack of specificity in the effective chemical agents. One of the workers who had established the stability of the naturally-occurring primary organizer substance to boiling, Holtfreter, made the further remarkable discovery that those parts of the gastrula (such as yolk endoderm and ventral ectoderm), which do not normally possess any inductor activity, will acquire it if they are subjected to boiling or to any treatment which will denature their proteins. This can only be interpreted to mean that the active substance for which we are looking is contained in masked form in the only tissue, *i.e.*, the ventral ectoderm, on which the activity of any substance can be tested. The effect of any chemical substance or fraction implanted into an embryo, therefore, may be indirect, by liberating the naturally-occurring substance from its inactive combination in the ventral ectoderm, rather than direct, by virtue of its chemical similarity to the naturally-occurring substance in the living inductor.

It is not easy to see how this difficulty will be overcome, but it would seem that the smaller the amount of a substance required to bring about the effect, the more likely it is that it is acting directly rather than indirectly. With this in view, Shen made a series of implantations of the carcinogenic hydrocarbon 1, 2, 5, 6-dibenzanthracene as its water-soluble derivative, the α - β -endosuccinate. The optimal activity was found at about 0.001 γ per gastrula, suggesting that the action of this hydrocarbon, at any rate, is direct rather than indirect. The fact that many hydrocarbons, both carcinogenic as well as estrogenic, together with some of the normal sex hormones, are especially

effective (Waddington & Needham) had already been discovered as a result of the suggestive first investigations in which activity was detected in the unsaponifiable fraction from the embryos.

Another important fact in the situation is that nearly all the adult tissues of all phyla possess the power of performing neural inductions. That adult tissues may work in this way was discovered by a number of investigators simultaneously, but we owe to Holtfreter the thorough survey of the field. He found that the tissues of vertebrates are rather more effective than those of invertebrates, and it is significant that they do not by any means all require to be boiled. From this one must infer that the naturally occurring organizer substance is sometimes present free in adult tissues, and this fact may not be without significance for the pathology of those puzzling formations, the teratomata. Activity has been sought for in plant tissues by many workers (Ragozina; Toivonen, etc.), but a study of the results shows that in no case have satisfactory inductions been obtained. Similarly many attempts have been made to produce neural inductions by mechanical irritation or local injury by heat, but here again, in spite of various claims, no satisfactory evidence has up to the present time been brought forward that this is possible (cf. Margen & Schechtman). On the other hand, weak inductions have been obtained by the implantation of rather large amounts of inorganic matter such as kaolin (Okada), but in this case severe degeneration of the cells surrounding the material was seen, and the author himself attributed the inductions to the liberation of the naturally-occurring substance by injury to the cells. Probably the inductions which have been reported as resulting from the implantation of jellies of very high and low pH (Barth), must also be placed in this category.

There can be little doubt that future research will come back more to the study of the substances contained in the embryo itself rather than the implantation of substances which it is not likely to contain. If it were possible to prepare an extract of the blastula, for instance, which would not induce in the fresh state but would only do so after denaturation of the proteins, it might be possible to fractionate the proteins in such a way as to insure that the masking complex alone was present. In this way we could approach the isolation and identification of the naturally-occurring primary organizer substance.

One might perhaps emphasize some of the difficulties which stand in the way of these investigations. In the first place the work cannot really be carried on satisfactorily except during the relatively short laying period of the newts every spring. The implantation process, too, is not one which it is easy to do on a mass-production scale,

nor can it readily be entrusted to technical assistants. Moreover, the impossibility of ascertaining the result from the mere inspection of the exterior of the embryo necessitates laborious serial-section cutting. Finally, the embryos do not tolerate the implantation of chemical substances and fractions nearly as readily as they do animal tissue whether living or dead.

The apparent lack of specificity in chemical aspects of neural induction, even though the cause for it may to some extent be understood, invites the very legitimate question as to whether there could be any analogy between neural induction in vertebrates and artificial parthenogenesis in echinoderms. There also a wide variety of substances and treatments will bring about the effect. It is not easy to obtain an answer to this question, for the subject of echinoderm parthenogenesis has been rather left on one side for some years past and no one seems to have critically evaluated the older literature in the light of modern conceptions. But in the first place it will be seen from what has been said above that the agents which will bring about neural induction in the amphibian embryo are distinctly fewer than those which will effect parthenogenesis in echinoderms. Moreover, the occurrence of auto-parthenogenesis (which would correspond to homoio-genetic induction) seems not to have been fully established. There does not appear to be any real reason for supposing that in fertilization or parthenogenesis any active substance is liberated from previous inactive combination. On the whole the parthenogenesis of echinoderms gives the impression of resembling rather the stimulation of a nerve than the process of induction by primary or secondary organizers in vertebrate development.

Turning now to the metabolism of the gastrula, it is fairly evident that we shall not know much about the process of liberation of the primary organizer substance until we understand better the metabolism of the various regions of the gastrula. Up to the present time it had not been possible to approach this subject, for lack of technical methods sufficiently delicate. The first observation of importance was that of Woerdeman who found by histo-chemical methods that glycogen disappears at the dorsal lip of the blastopore during the invagination process. Although subjected to the criticism inevitable where histo-chemical methods are used, this fact was established by direct micro-chemical analysis by Heatley at Cambridge in the first straight chemical work ever done on the regions of the amphibian gastrula. On the other hand Brachet at Brussels was the first to make measurements of respiratory rate, etc., of the different regions of the gastrula, but the techniques he used were only approximative. The Cambridge group have since then made a thorough survey

of the metabolic qualities of the gastrula regions, comparing dorsal lip with ventral ectoderm, with the aid of the Cartesian diver micromanometer.

This micromanometer, suggested for biological use by Linderström-Lang, is from 1500 to 2000 times more sensitive than the Warburg manometer. The pieces used were of the order of 100 γ dry weight, and the total gas turn-over in each case was between 50 and 300 $\lambda \cdot 10^{-3}$. Respiratory quotient is obtainable on a gas turnover as small as 50 $\lambda \cdot 10^{-3}$. The amounts of the tissue used were measured by a new micro-Kjeldahl method measuring as little as 1 γ total nitrogen.

The anaerobic glycolysis and the anaerobic ammonia production turned out to be three times as high in the dorsal lip as in the ventral ectoderm (Boell, Needham & Rogers), but the oxygen consumption was found to be identical (Boell & Needham). This could only mean that the metabolism of the dorsal lip differed from that of the ventral ectoderm in quality rather than in quantity. Accordingly it proved possible to observe a difference in the respiratory quotient of the two regions. Both rise from 0.7 at the beginning of gastrulation towards unity, but the dorsal lip region rises very rapidly and completely, whereas it is doubtful whether the ventral ectoderm has attained a respiratory quotient of much above 0.9 by the time it is underlain by the mesoderm and can no longer be isolated by itself (Boell, Koch & Needham). As for the aerobic glycolysis, it turned out to be negligible in both regions, suggesting that the Pasteur reaction is equally efficient all over the embryo (Needham, Rogers & Shen).

Other investigators using different and in general less delicate techniques have reached various conclusions. The respiratory quotient difference has repeatedly been found by Brachet, but some workers, such as Fischer & Hartwig, have found a slight difference in oxygen consumption in favor of the dorsal lip. Brachet & Shapiro interpreted their experiments, in which an intact gastrula was held between two capillary manometers, to mean higher oxygen consumption in the dorsal lip, but the Cambridge group believe that these data can equally well be interpreted as meaning that there is a larger amount of highly respiring tissue contained in the dorsal lip hemisphere of the gastrula, than in the other hemisphere.

In this way it may be hoped that we shall begin to understand something of the chemical differences between the embryologically important regions of the gastrula. For example, Brachet has shown that the organizer center is characterized by proteins which exhibit a particularly high fixed-SH content on denaturation. These proteins first make their appearance in the nucleus of the oocyte and as development goes on come to oc-

cupy a position roughly similar to that of the organizer center. Brachet & Rapkine believe that neural induction is connected with the oxidation-reduction situation in the tissues, for they have indications that the occurrence of neural differentiation may depend upon the redox level of the solution. This may give significance to the studies now being made by Nowinski on the distribution of the highly-reducing ascorbic acid in the gastrula. It seems to occur both in ectoderm and mesoderm but not in the endoderm.

Perhaps it is not necessary to emphasize the importance of work on organizer phenomena for general biology. We know that organizers have a fundamental part to play in the development of all vertebrates, *e.g.*, birds, fishes, mammals, etc. In the invertebrates we know of two centers important for differentiation in insect eggs, and in the sea-urchin there are also two centers, though their function seems to be very different from those in insects. We are familiar also with many phenomena due to excess of organizers. These may be under considerable control, as in the case of twinning, which may even occur normally in all the individuals of a certain species, *e.g.*, the armadillo. But there may also be cases where organizer activity is not under control, as probably in the teratomata. Phenomena due to defect of organizers are also quite common. They may be produced experimentally as in the lens-less eyes of Lehmann, or they may be found spontaneously in vitamin deficiencies or in all probability in the action of very many lethal genes (*e.g.*, the otocephalic anomalies of Wright). It would not be too much to say that the knowledge of dependent differentiation which has grown up in the last half century has rendered an altogether new outlook possible on the relations between biochemistry and morphogenesis. For morphogenetic stimulating substances are molecules and hence subject to metabolic processes. And morphological architecture itself cannot but be based on the disposition of protein macro-molecules within the cells.

I would like to conclude by a few general remarks on this difficult problem. Philosophers have often talked about the reducibility or irreducibility of biological facts to physicochemical facts. These old controversies are unnecessary if we realize that we are dealing with a series of levels of organization. We must seek to elucidate the regularities which occur at each of these levels without attempting either to force the higher or coarser processes into the frame-work of the lower or finer processes, or to explain the lower by the higher. From this point of view the regularities discovered by experimental morphology will always have their validity and will be unaffected by anything which either psychology on the one hand or biochemistry on the other may discover. The

behavior for example of an isolated eye-cup will remain the same however much our knowledge of biochemistry may advance. This is the reason why prediction is possible at a level of organization which, strictly speaking, we do not understand at all (cf. genetics). But the important point is that although the regularities established at the level of experimental morphology will always hold good, they will, in the absence of biochemical experimentation, remain forever meaningless. Meaning can only be introduced into our knowledge of the external universe by the simultaneous prosecution of research at all the levels of complexity of organization, for only in this way can we hope to understand how one is connected with the others.

This brings up the ancient distinction between form and matter. Morphologists for many centuries past have devoted themselves to the study of form without any consideration of the matter with which it is indissolubly connected. In this they were perhaps influenced by the doctrine of Aristotle, who held that there could be form without matter but that there could be no matter without form. But the only entities which, according to him, possessed form without matter, were God, the demiurges that moved the spheres, and perhaps the "rational soul." All of these are factors

in which experimental science has never been very much interested. On the other hand he maintained that there could be no matter without form, for however pure matter was, it was always composed of the elements, that is to say it was always either hot or cold, dry or wet. Now this in its crude way mirrors the standpoint of modern science. Form is not the perquisite of the morphologist; it exists as the essential characteristic of the whole realm of organic chemistry and cannot be excluded either from inorganic chemistry or even nuclear physics. But at that level it blends without distinction into order as such, and hence we should do well to give up all the old arguments about the form and matter, replacing them with two factors more congruent with what we know of the universe today, that is to say, organization and energy. From this point of view there can be no sharp distinction between morphology and biochemistry, and we may have every hope that in the future we shall be able to see not only what laws the form of living organisms obeys at its own level, but also how these laws are related to the laws which operate at the lower levels of organization.

(This article is based upon a lecture given at the Marine Biological Laboratory on August 18.)

THE EFFECT OF GAMETE AGE AT THE TIME OF FERTILIZATION ON DEVELOPMENT AND THE COURSE OF GESTATION IN THE GUINEA PIG

DR. WILLIAM C. YOUNG

Associate Professor of Primate Biology, Yale University School of Medicine

Embryological and gynecological literature contains numerous suggestions 1) that defects in ova and spermatozoa may be responsible for at least some of the abnormalities of development and gestation in mammals, and 2) that such defects may be attributable to the age of the gametes at the time of fertilization. An opportunity to test this hypothesis was presented when it was found that in the guinea pig ovulation occurs about the end of heat and that artificial insemination can be accomplished before and after, as well as during, heat.

The effects of ovum age on development can be studied by inseminating the females a given number of hours after the end of heat which is the approximate time of ovulation and then observing the course of pregnancy.

The effects of aging on the fertilizing capacity of spermatozoa can be studied by inseminating the females shortly before heat is expected, observing them until the end of heat, which will be the end of the interval between insemination and ovulation, and by then observing the course of pregnancy.

The effects of ovum age at the time of fertilization on development and gestation were studied first, and have been described in detail (Blandau and Young, *Am. Jour. Anat.*, 1939). Briefly, it was found that as fertilization of the ovum was delayed there was a progressive increase in the number of sterile inseminations and in the frequency of abnormal development which was terminated by abortion, particularly during the first 27 days of the 68-day gestation period. Abortions also occurred later, but they were as common in the control as in the experimental group and were attributed to some other cause.

The complementary study which involved a determination of the effects of prolonged residence in the female genital tract on the fertilizing capacity of spermatozoa has recently been completed by Mr. Arnold L. Soderwall. In this investigation the limit of time during which fertilizing capacity was retained by spermatozoa introduced into the genital tract of the female was 22 hours. Prior to the 17th hour, no effect was observed as measured by litter-size, the percentage of fertile inseminations and the condition of the young. In

the case of litters born to females in which fertilization had been effected between the 17th and 22nd hour after insemination a decrease in the percentage of fertile inseminations and in litter-size was indicated, but in contrast to the result obtained following delayed fertilization of the ovum, no effect was seen on development or the course of gestation. No abortions occurred during the first 27 days of gestation and, as before, those which occurred after the 55th day were as common in the control as in the experimental series.

Completion of the second part of the study has enabled us to summarize the results of the entire investigation as follows:

Both the ovum and the spermatozoon of the guinea pig are short-lived cells, but in the case of the ovum there is a progressive impairment of

function which appears before the capacity for development is lost and which results in abnormalities of development and gestation that culminate in abortion, especially during the first half of pregnancy. In the case of the spermatozoon, on the other hand, normal development appears to be possible if fertilization is possible. No evidence has been found that abnormal development follows the fertilization of ova by spermatozoa which are near the limit of their capacity to effect fertilization. If this difference between ova and spermatozoa is common, the fact is not without significance that in many mammals the temporal relationship between heat and ovulation is such that spermatozoa await the release of the ovum.

(This article is based upon a seminar report given at the Marine Biological Laboratory on August 15.)

EXPERIMENTS ON THE PRODUCTION OF HAPLOID SALAMANDER LARVAE

(Continued from page 169)

which are in every respect normal. Also, haploid plants have been produced experimentally and these are viable though in most cases sterile.

The present experiments were undertaken primarily to test, with new methods, with the eggs of species which have not been used extensively before, the possibilities of extended haploid development in these species, as well as to extend the observations on problems of the cytology of the failure of haploid embryos and the problems of differentiation and regulation which take place in haploid larvae.

Two species of newts have been used: the common American newt, *Triturus viridescens*, and the Japanese newt, *Triturus pyrrhogaster*. The female chromosomes were removed from the eggs with a small pipette, and all subsequent development then took place by means of the male chromosomes.

In over 200 experiments on *T. viridescens*' eggs with this method, the results have been discouraging. It was found that only about 15% of the androgenetic embryos developed beyond gastrulation. The majority died during blastula and gastrula stages. Only one advanced larva was obtained. Many more experiments are necessary, and perhaps with other methods, before the range of haploid development in this species can be determined. It is possible that the experiments with cold temperatures which are in progress in the Princeton laboratory will do this (see Fankhauser, *Collecting Net*, vol. 14, no. 2, 1939). The haploid condition of this single advanced larva has been established by chromosome counts in the various tissues of the body. In a preliminary examination of the histology and anatomy of this

viridescens' larva, it seems safe to say that, as far as this animal had developed, differentiation and regulation have not been inadequate in the presence of the haploid, paternal set of chromosomes. A more detailed study of these two problems is under way at present.

The causes of death at the blastula and gastrula stages of development have been investigated this summer. It was found that the cells of all those blastulae and irregular gastrulae which had ceased development were equipped with subhaploid or superhaploid chromosome numbers in the majority of mitoses which could be analyzed. This is in agreement with Fankhauser's extensive studies on the causes of the high death rate in merogonic embryos of *Triton palmatus*. It seems, then, that in *viridescens* also, at least the full haploid set of chromosomes is necessary for an embryo to develop beyond the gastrula stage.

The results with the eggs of *pyrrhogaster* were far more encouraging, as far as the possibilities of obtaining advanced larvae are concerned. These eggs were obtained by implantations of the anterior pituitary lobe of frogs. Development of unoperated eggs was practically always normal. In 76 operations this spring, it was found that about 42% gastrulation took place, and about 30% of all embryos developed to stages ranging from a neurula to a 120 day-old larva. The tail-tip test on this advanced larva was not entirely convincing. There were some large nuclei present which resembled diploid nuclei of the controls. Cross sections of the tail made this summer show the animal to be haploid in some parts, haploid and diploid in others, and diploid in still other parts. The whole animal has not as yet been sectioned.

It was only slightly dwarfed as compared to controls and was therefore entirely unlike all other haploids which have ever been reared to an advanced stage of development. There was another advanced larva, however, which was fixed at 47 days of age, at a time when the hind limb buds had appeared. The upper jaw of this larva was deformed and for this reason the larva was unable to feed. Deformities of the jaw are not uncommon in controls, however. This animal was dwarfed in external appearance and rather sluggish in its reactions to stimuli. The tail tip test

looks convincing, but the animal has not been sectioned.

In summary, although more evidence is needed for the complete haploidy of the pyrrhogaster larvae in the last group of experiments mentioned above, it is apparent that with this particular method the eggs of *Triturus pyrrhogaster* are much more adaptable for the purposes of obtaining advanced haploid larvae than are the eggs of *Triturus viridescens*.

(This article is based upon a seminar report given at the Marine Biological Laboratory on August 15.)

ON THE NATURE OF THE MATERIAL ELABORATED BY FERTILIZABLE NEREIS EGGS INDUCING SPAWNING OF THE MALE

DR. GRACE TOWNSEND

Professor of Biology, Great Falls Normal College, Montana

According to the narrative of Just (1930), the observations of Lillie on the spawning reaction of *Nereis limbata* led to the formation of the "fertilizin theory". Lillie found evidence that material from eggs, and only from fertilizable eggs, induces the spawning of the male. He noted that after mingling with sperm, the material no longer induces spawning and believed this apparent binding of the material by sperm to be the same as occurring in the cortex during fertilization by which the egg becomes incapable of reacting with another sperm.

Several workers have claimed to have discovered a substance or substances essential in fertilization: Woodward (1918) dialyzed and fractionated egg-water to obtain a parthenogenetic fraction and an agglutinin fraction, Carter (1930) proclaimed thyroxine to be "fertilizin", Hartman (1939) proclaims echinochrome to be "fertilizin".

I have re-investigated the relation of the spawning inducing material to fertilization. As will be detailed below, I found the spawning inducing material to possess properties in common with material essential to egg activation though not necessarily associated by function with egg and sperm union. Egg-cell activation may plausibly involve processes common to all species and be based on the same processes as may initiate cell division in any tissue. Correspondingly, spawning of the male worm was found to be induced by extracts of many fresh tissues: fish muscle, liver and kidney, cat muscle, liver, kidney, adrenals, and spleen, and macerated Chaetopterus and Podarke tissues. Glutathione is found in the watery extracts of all fresh tissues and all were positive to the nitro-prusside test.

Crystalline pure glutathione in one part in a million in a single drop quantity, and the molecular constituent, cystine or cysteine, in higher con-

centration, induced the natural spawning reaction. Evidence was obtained to indicate that glutathione may plausibly be elaborated from the surface of the egg: (a) Microchemical tests demonstrated that glutathione is concentrated in the germinal vesicle. (Many eggs are not fertilizable until after rupture of the germinal vesicle and Lillie conceived the germinal vesicle as acting as a reservoir of "fertilizin".) (b) Titration of the glutathione of eggs, utilizing a modification of Tunnicliffe's method, indicated that eggs from various species contain from 300-700 mg. per 100 gm. wet weight, which is a very high value. (c) A reducing substance passes from Nereis eggs.

A comparison of the chemical sensitivity of the non-sexual and sexual phases indicated that during metamorphosis the male becomes greatly sensitized to glutathione while the general chemical sensitivities remain unchanged. The sense organs of the metamorphosed males can distinguish molecular configuration as shown by a twelve-fold greater sensitivity to the naturally occurring levocystine than to dextro-cystine. Altering the configuration of the molecule by binding the SH group with monoiodoacetic acid completely destroys the spawning inducing property of glutathione or cystine. The worms do not spawn in response to dilute solutions of other amino acids than cystine or cysteine, or to other sulphhydryl compounds than glutathione or its molecular constituents. Echinochrome or thyroxine do not induce spawning.

The properties of the spawning inducing material from Nereis eggs and glutathione are entirely in qualitative agreement: both are filterable, dialyzable, precipitated by acetone, relatively stable in acid, unstable in alkali, destroyed by boiling in sea-water, adsorbed by kaolin and charcoal, and both show the same relation to agents

which have been tested on fertilization. The spawning inducing property of either is not destroyed by KCN and this reagent permits fertilization (Blumenthal, 1930). A series of reagents known to inhibit egg-cell activation destroy the spawning inducing property of both egg-water and glutathione: Au, Cu, Zn, Pb, Ni, Co, As, Hg (Mercury requires a very high concentration relative to copper and other metals and this relationship may be associated with the difference of the effects of copper and mercury on fertilization described by Lillie in 1921), prolonged irradiation, blood and coelomic fluid from various animals, cytolysed eggs (Lillie stated an anti-fertilizin was freed by cytolysis of eggs). Lastly I ascertained that extracts of a large variety of cytolysed tissues—with the exception of sperm—destroy the spawning inducing property of egg-water and glutathione and likewise inhibit egg-cell activation. This latter would suggest that normal tissue contains material which may bind glutathione.

The properties of the spawning inducing material of egg-water and glutathione are in agreement with Woodward's parthenogenetic fraction in so far as tests correspond. With respect to filterability and dialyzability, the properties are contrasted to those of Woodward's sperm agglutinin and to Lillie's fertilizin where tested solely by sperm agglutination. The property of not being bound by sperm is also contrasted to Lillie's description of fertilizin. The specificity of the sperm-egg union might well be based on characteristically species specific globulins which have large molecules and would be non-filterable and non-dialyzable, as contrasted to a logically widely distributed material of cell activation. The property of being bound by sperm was suggested to Lillie by the apparent loss of stimulating property in the presence of sperm. Upon careful investigation it was found the sensitivity of the end organs is affected by sperm, and a sperm-egg mixture

is stimulating if added to males in fresh seawater. Since the cortical reaction in parthenogenesis—without the action of sperm—causes the loss of capacity to react with sperm, the property of inactivation by sperm is superfluous. A wave of cytolysis has been described as initiating fertilization and cytolysis frees material which binds glutathione.

Although the spawning inducing property of egg-water and glutathione are correspondingly destroyed by the same agents, for physiologically equivalent solutions, the egg-water is the more readily inactivated. This would be true if the egg-water is effective in more dilute solution than commercial glutathione. The elaboration of the spawning inducing material from the eggs is linked with their respiration and in the process of secretion or elaboration some complement may be added to the glutathione molecule rendering it more effective than the commercial form.

Lillie describes the loss of the fertilizability of washed eggs as being due to a loss of a fertilization essential substance. In a series of five experiments, I found the fertilizability of washed eggs to be partially restored relative to the control eggs by fresh egg-water or 1:4000 glutathione. In the tests made, I obtained similar results in removing the poisoning effects of monoiodoacetic acid and arsenic by addition of glutathione. Rapkine (1932) restored the fertilizability of eggs poisoned by copper or arsenic by addition of glutathione.

In conclusion, the spawning inducing material possesses all investigated properties qualitatively in common with glutathione and with a fertilization essential substance. It possess, in main, the properties ascribed to the "parthenogenetic fraction of fertilizin" by Woodward, and ascribed to the egg activating material (the ovophile portion of fertilizin) by Lillie.

(This article is based upon a seminar given at the Marine Biological Laboratory on August 15.)

INVERTEBRATE CLASS NOTES

When we returned to the lab from Cuttyhunk, we found—much to our dismay—that Dr. Bissonnette had not been losing any time. The six methods of zooid protrusion as seen in Bryozoa (with illustrations) filled the blackboards. We spent the next day considering the Bryozoa—learning their field characters, habitat, and anatomy in the short space of one day.

Thursday we trooped into lab to learn from Dr. Lucas the effects of the winds, waves, tides, and substratum upon the types of animals found in the littoral zone. At the close of the lecture we wandered to the steps of the brick building to be photographed for posterity. Since we had been

forewarned, we wore our old clothes and exposed our barnacle scratches.

We then embarked for Kettle Cove. As we steamed through the fog we scanned the skies for signs of a storm. This was the first cloudy field trip, (Dr. Bissonnette is notorious for his selection of fair weather for field trips) and some of our inland members were secretly hoping for a storm so that *mal du mer* could be added to their list of experiences.

Crustacea were numerous at Kettle Cove—Orchestia, Alorchestia, Jera, etc. The Lady Crab made a lasting impression upon a number of

(Continued on page 183)

The Collecting Net

A weekly publication devoted to the scientific work at marine biological laboratories.

Edited by Ware Cattell with the assistance of Boris I. Gorokhoff and Mona Garman.

Entered as second-class matter, July 11, 1935, at the U. S. Post Office at Woods Hole, Massachusetts, under the Act of March 3, 1879, and re-entered, July 23, 1938.

Introducing

DR. FRANZ WEIDENREICH, Director of the Cenozoic Research Laboratory of the Peiping Union Medical College in Peking.

Dr. Weidenreich, noted anthropologist, was born in Germany and studied at the universities of Munich, Kiel, Berlin and Strassburg, receiving his doctor's degree at the latter institution. He remained at Strassburg for a number of years as professor of anatomy, until the end of the World War, when the territory was annexed by France. He was thereupon obliged to resign, and became professor of anatomy at Heidelberg. In 1928 he was appointed professor of anthropology at Frankfurt, a position which he was again forced to leave in 1934. As he tersely expressed it, he was removed from Strassburg because he was a German, and he was removed from Frankfurt because he was not a German.

After a year as visiting professor of anatomy and anthropology at the University of Chicago, he accepted his present position at Peking, where he has been conducting research on fossil man, especially on *Sinanthropus pekinensis*.

Early in his career, Dr. Weidenreich worked on such subjects as spleen, blood, bone substance, pigmentation, and lymphatic system, etc. He has always been interested in anthropological questions, and has done considerable research on fossil man during the last few years. He has published books on leucocytes, the human foot, race and constitution, and fossil man.

Dr. Weidenreich arrived in the United States on his present visit in May of this year, and has been conducting research on comparative anatomy at the American Museum of Natural History. He visited Woods Hole for a few days early in July, and then left for a three weeks' trip to the Pacific Science Congress, where he presented papers on Pithecanthropus and on the Paleolithic man of North China. He returned to Woods Hole on August 14, and will do bibliographical work at the Marine Biological Laboratory library for the remainder of the summer.

DATES OF LEAVING OF INVESTIGATORS

Beams, H. W.	August 24
Clement, A. C.	August 17
Denstedt, O. F.	August 23
Evans, T. C.	August 25
Gustafson, A. H.	August 14
Needham, J.	August 23
Neufeld, A. H.	August 23
Porter, K. R.	August 21
Sturdivant, H. P.	August 23
TeWinkel, Lois E.	August 19
Wilhelmi, R.	August 18

The name of the Eugenics Record Office at Cold Spring Harbor, Long Island, New York, has been changed to Genetics Record Office. This office is associated with the Department of Genetics of the Carnegie Institution of Washington.

The United States Bureau of Fisheries has recently been transferred from the jurisdiction of the Department of Commerce to that of the Department of the interior.

A United States Bureau of Fisheries Laboratory is being constructed on the coast of the Gulf of Mexico, about seven miles from Pensacola. Located on a small island connected with the mainland by a bridge, the laboratory is being remodelled from an abandoned quarantine station by the W.P.A. The station is in a region containing a wide variety of marine habitats and is well protected from storms. The building has been considerably enlarged and consists of six research rooms, a chemical research room, a dark room, a stock room, an office, a library and a museum. Living accommodations are available for about fourteen investigators, in addition to the regular staff of the station.

CURRENTS IN THE HOLE

At the following hours (Daylight Saving Time) the current in the Hole turns to run from Buzzards Bay to Vineyard Sound:

Date	A. M.	P. M.
August 26	2:26	2:41
August 27	3:18	3:24
August 28	3:59	4:07
August 29	4:33	4:51
August 30	5:13	5:27
August 31	5:52	6:09
September 1	6:29	6:44
September 2	7:06	7:28
September 3	7:47	8:07
September 4	8:26	8:57

In each case the current changes approximately six hours later and runs from the Sound to the Bay.

ITEMS OF INTEREST

The *Atlantis* will sail on Monday for a cruise of four or five days to obtain bottom mud cores from the continental slope and the continental shelf south of Woods Hole under the direction of Mr. Henry Stetson. The ship returned Tuesday evening from a trip to make routine observations on the strength of the Gulf Stream.

DR. C. A. ANGERER, instructor in zoology at the University of Pennsylvania, has been appointed instructor of physiology at the Ohio State University Medical School.

DR. ARTHUR H. WEYSSE, who retired as professor of biology at Boston University a year ago, has recently been given the rank of Professor Emeritus.

DR. GIOACCHINO FAILLA, director of the Department of Experimental Radiology at the Marine Biological Laboratory, will be chairman of the Section of Biophysics of the Third International Cancer Congress, which will meet at Atlantic City, N. J., from September 11 to 15.

DR. VALY MENKIN, who has been working at the Marine Biological Laboratory this summer, will read a paper before the International Microbiology Congress entitled, "Mechanics of Inflammation in Relation to Immunity."

PROFESSOR GEORGE W. BEADLE, of Stanford University, is giving courses in genetics in the University of Illinois this summer. He spent the summer of 1937 at the Marine Biological Laboratory.

DR. RAYMOND B. MONTGOMERY, a member of the staff of the Woods Hole Oceanographic Institution, will arrive in Woods Hole early next week. He has been studying at Berlin, Bergen and Helsingfors under a National Research Council Fellowship and has just returned to the United States.

DR. CHARLES E. RENN presented two papers at the Staff Meeting of the Woods Hole Oceanographic Institution last Thursday. Their titles were: "Adsorption of Nitrogenous Organic Matter on Marine Muds," and "Respiration Studies on Relative Quantities of Net Plankton and Nanoplankton."

MR. WILLIAM CHAMBERS, son of Dr. Robert Chambers, acted as ship's surgeon and technical scientific assistant on the recent trip of the *Atlantis*.

At the Penzance Forum tomorrow afternoon Mr. George W. Shepherd, an advisor of General Chiang Kai-Shek, will speak on "What's Going on in China."

DR. AND MRS. JOSEPH NEEDHAM left Woods Hole at the middle of this week and will spend several days in Cold Spring Harbor before sailing back to England on the S.S. *President Harding* on August 30. Mrs. Dorothy M. Needham is specializing in muscle biochemistry.

DR. V. EKMANN left Woods Hole on Friday afternoon after a two weeks' stay at Woods Hole. Earlier in the week he had made a short trip to Nantucket.

DR. KENNETH C. BLANCHARD, associate professor of chemistry at New York University, and Mrs. Blanchard have completed a visit of several days at Woods Hole. They had previously spent some time at his father's cottage in Nantucket.

DR. I. I. RABI, professor of physics at Columbia University, visited Woods Hole on Tuesday with his wife.

MRS. ETHEL BIRRELL RAMSDEN, of the science department of the State Teachers' College, Keene, N. H., visited Woods Hole for a few days this week to confer with workers in the field of endocrines. She took the invertebrate course at the Marine Biological Laboratory in 1924.

J. W. WICKENDON, head of biology at Deerfield Academy, is at Woods Hole this summer for the first time since 1929, when he took the course in embryology at the Marine Biological Laboratory. He is accompanied by his wife and child.

DR. PURNENDU CHAKRAVORTY, research associate in biochemistry at Princeton University, returned to Princeton last week-end after a visit of three and a half weeks at Woods Hole.

MISS RUTH RAWSON, an assistant in the department of physiology at the College of Physicians and Surgeons, is spending two weeks at Woods Hole.

MISS NANCY EGGLESTON visited Woods Hole last week-end while on her way to join her parents on Martha's Vineyard. Miss Eggleston, who worked at Woods Hole in 1937, will be a graduate student at Cornell University this fall.

Donations are being collected to improve the M.B.L. bathing beach by the construction of a 150-foot rock jetty to prevent sand on the beach from being washed away during storms. It is also planned to remove rocks now on the beach and to deposit sand in their place.

A benefit dance will be held Tuesday, August 29, at the Breakwater Hotel. Entertainment, including a skilled magician, will be featured at the dance. Tickets are being sold for \$1.00 each; donations may be sent to James McInnis at the Supply Department.

ARBACIA

DR. ETHEL BROWNE HARVEY

Research Investigator, Department of Biology, Princeton University

The season for Arbacia eggs is approximately June 15 to August 15 for animals living in the Bay and Sound around Woods Hole. Before this the eggs are immature, in the germinal vesicle stage; and after this most of the animals have shed, and although one can still obtain good sperm, the gonads are small and there are few eggs. While remaining at Woods Hole late one fall, I found that I could still obtain eggs in abundance from the Arbacias which had been in the aquaria since July. It is now an established fact that the animals, if brought in early in the season (July or early August) and kept in the aquaria, large or small, with running sea water, will retain their eggs and provide material for experimental work throughout August and early September. The animals require no food but apparently they eat each other. It is very necessary to see that they are not overcrowded (150-200 in the average size aquarium) and that there is a steady flow of fresh sea water. Any adverse conditions cause the animals to shed; overcrowding or failure of the sea water to flow or pollution of the water. It is very necessary for each investigator to oversee the flow of sea water into his aquarium tanks, as the pipes frequently get stopped up by organisms which have settled there and grown, and the current of sea water is thus cut off. It is well to turn the stop-cocks and flush out the pipes with a full flow of sea water once a day after August first. Since the Arbacia tend to shed in the live cars where they are stored, it is essential that each investigator provide himself with his own supply of sea urchins for use after August tenth. It would be helpful to the Supply Department if the investigators start storing up their urchins early in the season. A few urchins with eggs may be found in lots brought in until September first, but many animals must be opened before a good one is found. The eggs are slightly different late in the season; the cleavage is slightly retarded irrespective of temperature, the eggs break less readily with centrifugal force and some pigment granules remain in the light half after centrifuging.

In preparing the animals for experimental work, wash them under the fresh water faucet a moment to kill any sperm adhering to the shell. Take the animal, oral (teeth) side up, and cut around the shell with scissors at about its widest circumference; then remove the upper (oral) part of the shell. The five gonads are now in view in the lower part, the ovaries red, the testes white.

To prepare the eggs for experimental work,

run a pair of curved forceps gently under an ovary, to snip the duct, and then remove it intact to a finger bowl about a quarter full of fresh sea water. Remove the other four ovaries in the same way. Contrary to the prevalent opinion, the fluid in the body cavity is not toxic to the eggs. Let the bowl stand for five or ten minutes so that the ripe eggs may flow out of the ovaries. Then put a piece of cheese cloth whose holes are five to ten times the diameter of the egg (*i.e.* about 0.5 mm.) and which has been wet with sea water, over another dry finger bowl and pour the egg suspension through. The debris and pieces of tissue will be held back and you will have eggs free and clean in the dish, ready for use. If one wishes to keep the eggs for several hours, there should not be too many eggs in the dish, just enough to form a thin layer on the bottom. The bowls of eggs are best kept on the floor of the cement aquarium tables where cool water will flow around them and they should be kept covered to prevent evaporation. The eggs treated in this way are suitable for use throughout the day though they change slightly on standing. Individual batches of eggs vary greatly in shape, percentage of fertilization, reaction to centrifugal force, etc. Any batch which does not give 98% fertilization membranes or which shows abnormalities in cleavage should be discarded.

Another method of obtaining eggs, sometimes used in the laboratory, is to let the eggs drain from the opened female through the genital pores into a dish. However, I find that any contact of the outside shell with the eggs in sea water makes the medium toxic to the eggs and they are unfertilizable. The fact that it is the material on the outside of the shell that is toxic and not the intestinal or body fluid inside can easily be demonstrated by keeping an opened female half covered with sea water and testing the eggs which have come through the genital pores and those which remain inside the shell. Those outside are not fertilizable, those inside are.

The testes should be removed with curved forceps in the same way as the ovaries, but put into a small salt-cellar or a very small Stender dish (3 cm. diameter) *without water*. This dish should be covered and kept cool. The sperm are inactive when kept concentrated but become active in sea water, soon wearing themselves out. I find a convenient method of fertilizing eggs is to dip a toothpick into the dish of sperm, just coating the tip and put this into the dish of eggs to be fertil-

ized, stirring slightly. With a little experience it is easy to control the amount of sperm you take up on the toothpick. This method seems to me less trouble and just as accurate as diluting a measured amount of the sperm with a measured amount of sea water, which must be done anew for each series of fertilizations since the sperm, once diluted, do not keep. Since the "dry" sperm varies so much in consistency in different lots and even in different regions of the same lot, adding a drop of "dry" sperm to a measured amount of sea water cannot give any very accurate, reproducible concentration.

After opening a male, care should be taken to prevent contamination of females opened subsequently. Scissors and forceps should be thrown, immediately after opening an animal, into a bowl of tap water and one's hands should be thoroughly washed.

The rate of development of the eggs varies of

course with the temperature, one degree C. causing a difference of five minutes in cleavage. At 23° C., first cleavage takes place in 50 minutes, the blastulae begin to swim in 9 hours and well-formed plutei have developed in 24 hours. The time for first cleavage is usually taken as the time when 50% of the eggs have cleaved. A series of photographs of the living egg at different stages in development may be found in *Turtox News* for October, 1938.

The unfertilized Arbacia egg averages 74 μ in diameter, the nucleus 11.5 μ . The egg is covered with a layer of jelly, invisible unless surrounded by particles of India ink, or better, lightly stained with Janus green. This jelly layer extends out 20-30 μ from the surface of the egg. The eggs, therefore, if in good condition, are not contiguous, but are well separated from each other by the jelly layers. The jelly may be dissolved off with dilute HCl (1 drop N/10 HCl to 50 cc. sea water).

BOOK REVIEW

OSMOTIC REGULATION IN AQUATIC ANIMALS.

By August Krogh. Illustrated. 242 pp. \$4.00. Cambridge: At The University Press; New York: The Macmillan Company. 1939.

Living cells normally contain certain inorganic ions such as Na, K, Ca, Mg, Cl, etc. in certain suitable concentrations. It follows that the cells and body fluids of fresh-water animals must considerably surpass the outside fresh water in osmotic concentration. Since the body surface, or part of it, is usually fairly permeable to water, and since the body usually cannot withstand any great mechanical outward pressure, some active mechanism is required to maintain this difference of concentration. In addition, in very many animals, both in the sea and in fresh waters, the relative proportions of ions within differ from those outside. Existing knowledge of the occurrence and nature of the mechanisms which maintain these differences of concentration and composition is reviewed in Professor Krogh's admirable book.

Professor Krogh did not find it practicable to arrange the data according to the types of mechanism involved, and so the subject is treated systematically, phylum by phylum; and for each phylum a very thorough account is given. The available information is treated critically and cautiously, and with detailed reference to the literature. In each case a brief account is first given of the relevant anatomical organization of the animals. After the higher vertebrates there follows a chapter on osmotic conditions in eggs and embryos. Next comes a very interesting section in which various cases of ion transport (including the kidney, intestine, body surface of some fresh-water animals, and plants) are summarised comparatively. This subject is treated with the greatest caution, and the pertinent facts are recorded without

reference to the various more or less speculative theories which have been proposed. A short note is given on possible future lines of research. Next there is a chapter on methods, in which reference is made to the most useful means for determining total osmotic concentration, concentration of various ions, and other practical matters. Finally there is an extremely valuable bibliography, covering the useful literature; and an index.

Mechanisms for the removal of the excess water which enters by osmosis, such as kidneys or contractile vacuoles, exist in many animals. But it is clear that if salts are lost at all there must be some means of replenishing them. In some cases the food may be an adequate source of salts. But it is shown by the author that a number of fresh-water animals can take up salts through some part of the body surface. In simple cases it is shown that Cl is taken up in exchange for HCO₃, and Na for NH₃. However this mechanism will not account for all cases of ion transport or accumulation, and the author refuses to indulge in speculation without adequate data.

It is not possible to summarise adequately individual chapters, as the material is naturally extensive and diverse. For the Protozoa attention is drawn to an old and little known report on Noctiluca, in which the regulation of specific gravity is attributed to NH₄Cl. The retention of ammonium may be ascribed to the acidity of the cell interior, which is sufficient to keep it ionized. Osmotic regulation in Protozoa is ascribed to the contractile vacuole, and no data are available on the uptake of salts from the exterior.

It is surprising that so little is known of osmotic regulation in the fresh-water and brackish-water coelenterates. For the estuarine triclads

turbellarian Procerodes (= Gunda) the idea of active resistance to osmotic inflow of water is rejected. Instead the author suggests regulation by the flame-cell system, although this has not been demonstrated. In any case it seems that much remains to be done with the Turbellaria. For estuarine polychaetes such as *Nereis diversicolor* there is again much doubt as to the extent to which active osmoregulation takes place rather than passive volume regulation by loss of water and salts. The possible action of the muscles of the body wall in driving fluid from the body cavity out through the nephridia is however not considered. For Crustacea important work on the kidney is summarised, and the active uptake of salts from the external medium is ascribed to the gills.

The excellent chapters dealing with insect larvae, elasmobranchs, and teleosts are of especial interest, and much important work is treated critically. It is interesting that Professor Krogh considers that the high urea content of elasmobranchs may indicate a marine rather than a fresh-

water origin for this group. There would be no object for a fresh-water organism to substitute urea in place of much-needed salts and thereby add to its osmotic difficulties. It is also suggested, in view of conditions in marine elasmobranchs and teleosts, that a vertebrate for some unknown reason requires to have a relatively low total concentration of salts. For Amphibia uptake of salts through the skin is again demonstrated. Much interesting information is presented for eggs and embryos, but the data are too diverse to summarise.

In conclusion the absolute soundness and caution of this book must be stressed. The author is critical throughout, and while retaining a wide breadth of vision he confines himself to solid facts and justifiable theory. The book is clear, readable, interesting, and liberally provided with tables and text-figures. In addition it will prove invaluable as a guide to those undertaking research in this field.

—J. A. KITCHING

REGULATION IN MOSAIC EGGS

DR. ALEX B. NOVIKOFF

Instructor in Biology, Brooklyn College

Evidence has slowly accumulated to demonstrate that there is no fundamental distinction between mosaic and regulative ova. Among regulative eggs, where embryonic induction is a prominent feature of development, mosaic features are also found, while in mosaic eggs a number of regulations have been discovered, with indications that embryonic induction may play a role in early development. In 1929, E. B. Wilson suggested that the polar lobe of such eggs as *Dentalium* may function as an organizer. But to test this hypothesis as well as to gain information concerning regulative processes generally, it does not suffice for one to separate the blastomeres, because the isolated cells may continue to self-differentiate and yet possess other, hidden potencies. Decisive evidence can be educed from transplantation experiments.

In normal development of *Sabellaria vulgaris*, a polar lobe is formed during each of the first 3 cleavages. The first lobe is incorporated into the CD blastomere, and the second and third into the D cell.

The polar lobe can be removed from the egg by means of a fine glass needle, once the egg membrane has been dissolved. Removal of the first polar lobe results in the loss of both the post-trochal region and the apical tuft. Removal of the second lobe results in the loss of only the post-trochal region, while the apical tuft is not affected. Presumably some material moves away from the vegetal region of the egg between the time of the

first and second cleavage. This material later has its effect on the apical end of the egg.

First and second polar lobes were transplanted at the first and second cleavages to whole eggs, to eggs from which the first polar lobe had been removed, and to isolated AB blastomeres. Within limits, differentiation progresses normally—not fundamentally altered by previous contact with the lobe. Apparently the materials in the polar lobe which are involved in the formation of the apical tuft and the post-trochal region do not diffuse from the transplanted lobe into adjacent cells.

That the contact of the lobe with the adjacent cells is close enough for some substances to diffuse across can be demonstrated by staining the lobe with Nile Blue Sulphate before transplanting it. The tissues in contact with the lobe are stained a pronounced blue by the diffused dye.

Transplants were also made of the CD, C, and D blastomeres. These cells contain some of the materials, either in the same of altered form, that are present in the polar lobes. The resulting embryos show duplications of apical tufts and post-trochal regions, but in all cases these duplications are due to the self-differentiation of the transplants. The development of the host cells has not been altered by the transplants.

Since the polar lobe, as well as any of the quarter- or half-blastomeres, does not affect the differentiation of adjacent cells through contact, it is not possible to consider the polar lobe as an 'organizer' in the sense of Spemann. It would ap-

pear that in the developing *Sabellaria* egg we have a mosaic each of whose parts develops by its own power, irrespective of neighboring cells or tissues.

In the course of these experiments one equally-cleaved egg was found. The two blastomeres of this egg were separated at the two-cell stage. Each cell produced polar lobes in the succeeding two cleavages and each gave rise to a larva possessing an apical tuft. The fact that each cell formed polar lobes and that the two cells were equal in size indicates that each cell had received materials from the first polar lobe. It would, then, appear that some material, present in the first polar lobe, *does* have the ability to change the course of development of a cell, but that this material does not act by contact; rather it must become a part of the cell. One may test this idea by distributing this material to cells which do not receive it in normal development.

In 1902, F. R. Lillie found that the addition of KCl to sea water inhibited cleavage in eggs of *Chaetopterus*. In spite of the absence of cleavage, the regular, apparently normal, flow and distribution of the cytoplasmic materials occurred.

If KCl would inhibit cleavage of the *Sabellaria* egg without interrupting the flow of materials which normally occurs between the first and second cleavages, and if on return to sea water, cleavage would ensue, then the first two blastomeres might both contain polar lobe materials.

This summer, I found that eggs placed in a 7.5% solution of 2.5 Normal KCl in sea water, would not cleave until returned to normal sea water. Eggs were allowed to develop normally until both polar bodies had been extruded. They were then put into the KCl solution until the controls had passed the first cleavage and the first polar lobe had been absorbed by the CD blastomere. At this time they were returned to sea water. Eight hours after the time of fertilization, one can see two kinds of larvae swimming in the cultures: one possessing the normal elliptical shape; the other triangular in shape. The triangu-

lar larvae develop into perfect double embryos. They have two eye spots, two sets of post-trochal bristles, two posterior cilia, two sets of dorsal cilia, two neurotrochs, two intestines, one central stomach, probably one oesophagus, one mouth and two mouth folds. As many as 90% of the larvae obtained after this treatment may be 'doubles'.

It is obvious that at least some cells have developed into structures which they do not form in normal development; in other words, the prospective potency of these cells is revealed to be wider than the prospective fate. This is a characteristic generally associated with regulative eggs.

If eggs are allowed to develop normally in sea water up to the completion of the first cleavage and the absorption of the first polar lobe by the CD cell, and are then placed into the KCl solution, until the controls finish the second cleavage, we find no double embryos; instead we find some larvae with extra bristles, some with extra eye spots, and some with both.

If some cells in these larvae have developed into structures which they would not normally form, this does not occur in so clear-cut and striking a manner as in the double embryos. In the double embryos we have two complete embryonic axes, with some fusion along the mid-line. One is reminded of the double embryos obtained by splitting the gray crescent of the amphibian egg, and we are brought again to the question: Can the polar lobe be considered an organizer? It does not act by contact, as does the amphibian organizer. But once in a cell, it does act like an organizer by inducing (if we may use the term) a new embryonic axis. It appears that double embryos do not normally occur in the *Sabellaria* egg because the organizing materials are confined to a particular portion of the egg which is separated at the first cleavage from the rest of the egg by a cell membrane across which no diffusion of the material occurs.

(This article is based upon a seminar report given at the Marine Biological Laboratory on August 15.)

INVERTEBRATE CLASS NOTES

(Continued from page 177)

people. Charlie Metz found one, and at the risk of life and limb, threw it into a sieve. "What a pretty thing," exclaimed Al Samorodin. "It looks as if it has a long reach." He then picked it up in the approved fashion and found that it had—a cheliped fastened itself to one of his digits. It has been said that his shout was heard distinctly all over the island.

Despite inclement weather, Sunday morning found us in lab reading the newspapers, writing letters, and listening to the radio. When Dr. Rankin bustled in about noon, he was greeted by the sight of semi-reclining bodies on chairs and tables and an intellectual conversation, the topic

of which was "The Relative Merits of Flash Gordon and Casper Milquetoast." "Is this a country club or something? It's a fine thing," he stormed when he regained his composure.

Little work was accomplished by the Invertebrates, for the more hardy souls hitch-hiked to Falmouth to see *The Wizard of Oz* (adv.) and the rest of us stayed to see Father Ludwig's Technicolor movies of a Field Trip.

The lecture on Phylogeny by Dr. Matthews was thought-provoking and one of the best given so far. We liked his Spoonerism, too—"the sweet frimming forms."
—Irene Ehrmann

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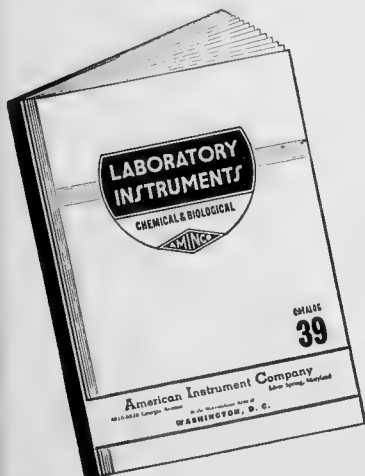
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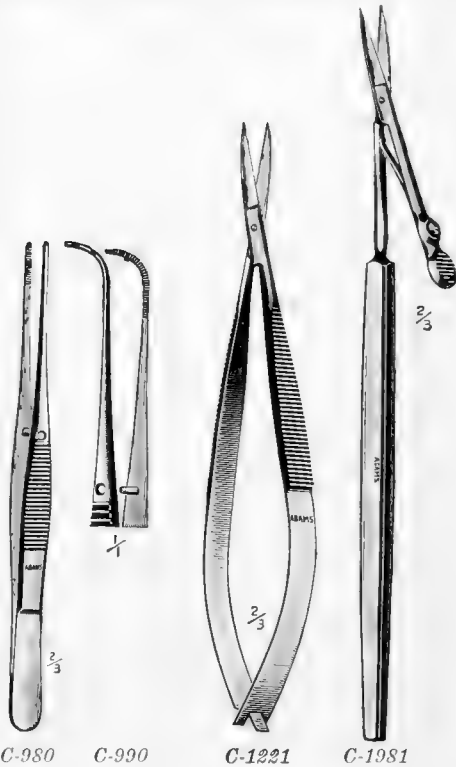
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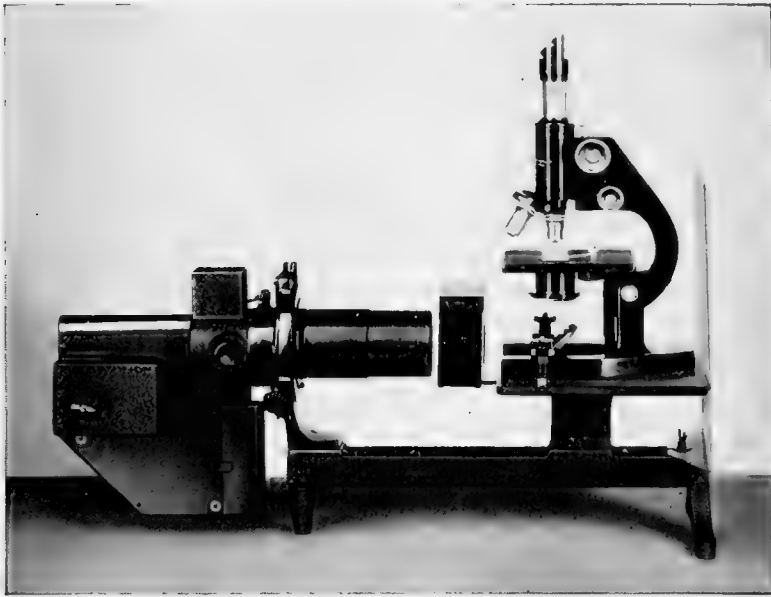
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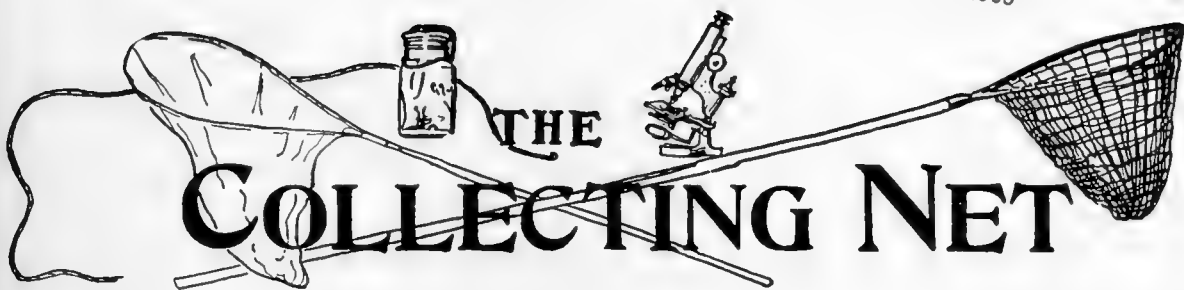
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Case histories are also presented to show the changes in position from day to day of the relatively stable cutaneous nerve endings which belong to myelinated fibers. These (Continued on page 197)

THE RELATION OF CELL TO ORGAN IN PLANT DEVELOPMENT

DR. EDMUND W. SINNOTT
*Professor of Botany,
Columbia University*

The Cell Theory, one of the greatest of biological generalizations, is undergoing this year a critical re-examination, since 1939 marks the centennial of the famous publications of Schleiden and Schwann which have commonly been regarded as promulgating the theory. I wish to discuss tonight certain implications of this theory for the general problem of organic development and to consider these particularly in the light of some new evidence from plants.

The idea that most organisms are composed of many unitary elements and that growth and development result from the multiplication of these units is obviously of great significance. Many biologists have agreed with Schwann that "the whole organism subsists only by means of the reciprocal action of its single elementary parts," and regard the organism as a society or commonwealth of cells, with laws governing the relations between its cellular units.

M. B. L. Calendar

The series of evening seminars and lectures at the Marine Biological Laboratory for 1939 has been completed.

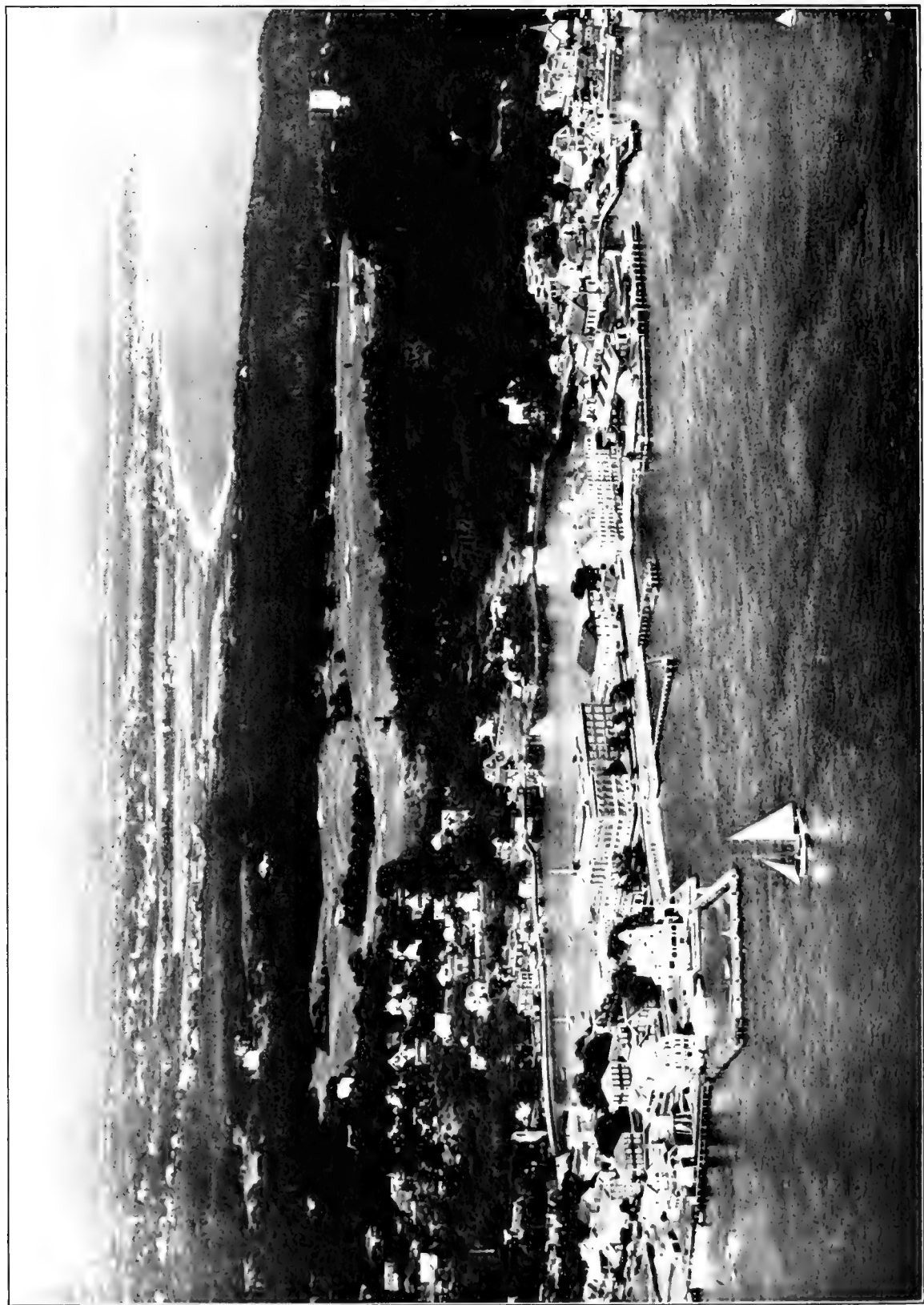


The Business Office of the Marine Biological Laboratory will be closed on September 4 because of the holiday.

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Photograph by Howard M. Wood, New Bedford, Mass.

AN AERIAL VIEW SHOWING THE LOCATION OF THE THREE BIOLOGICAL LABORATORIES IN WOODS HOLE

The fact that cells which are separated naturally or by mechanical means will sometimes aggregate themselves into an organized body supports such a conception. Biologists have been so impressed with this point of view that many are inclined to approach all problems of morphology and physiology by way of the cell. It has often been pointed out, however, notably by Professor Whitman¹ in one of these lectures nearly fifty years ago, that the developmental relation of cell to organism was not as simple as this, and that the organization of the individual involves more than a series of complex intercellular reactions.

The question can be studied most directly in the relation between cell and organ rather than between cell and organism; and plant material is especially serviceable here since in most plants an extensive series of homologous organs is available in a single individual. The fruit is particularly favorable since it is of less physiological significance than the leaf or the flower. The fruits of members of the family Cucurbitaceae and especially two of its members, *Cucurbita pepo* and *Lagenaria vulgaris*, are most useful since in each of these there is very great diversity in size and form of fruit between various races. It is primarily by a study of material from this source that we shall seek an answer to this question: Is the development of an organ dependent on the interaction between its component cells, as organized systems, or has it an independent organization of its own?

Evidence from Size

1. *Cell Size and Organ Size.*—The most direct evidence bearing upon this problem is that derived from a study of the relation between cell size and organ size. In a number of pure races of the two species mentioned, cell size was measured at various ovary sizes from very small primordia to mature fruits, and in five tissues—the placental region, the inner, middle and outer walls, and the epidermis. Early growth in each is chiefly by cell division and later growth entirely by cell expansion. There is a gradient from within outward in rate of cell increase in size during the period of division, and in the time of cessation of division. The duration and the extent of both cell division and cell expansion is markedly different in different races. Although this general developmental schedule thus varies considerably, it is noteworthy that the growth of the fruit as a whole always proceeds at a constant rate throughout early growth and then falls off regularly to maturity.

(1) Whitman, C. O. The inadequacy of the cell theory of development. *Jour. Morph.* 8: 639-658. 1893.

turity, and that the growth curve is very similar in the different races.

2. *Cell Division and Growth Rate.*—In certain races, cell division ceases in all the tissues at approximately the same time. When growth of the fruit is measured, its rate before this point is found to be exactly the same as for some time afterward. Growth proceeds at the same rate, whether it is due to cell multiplication, to cell expansion, or to both combined.

3. *Meristematic Cell Size.*—As has been recently shown by Whaley, cell size at the meristem progressively decreases during the development of the tomato plant, even though the plant as a whole is growing at a constant rate. This same behavior seems to be true of all plants with a limited growth cycle. Evidently embryonic cell size (at the meristem) has little relation to rate of growth.

4. *Cell Elongation During Growth.*—In the growth of a root in length, cell division at the apex is followed by a "wave" of cell elongation, which proceeds toward the tip. A study of cell behavior in living plant roots shows that this wave reaches the basal end of each cell first, so that the cell does not elongate uniformly but grows more rapidly first at its basal end and then at its apical one.

In all these cases, the organ is the structure which shows the simplest behavior and seems to be developing as a unit, with no close relation to the manner in which it happens to be cut up into cells.

Evidence from Form

1. *External Form.*—The wide variety of fruit shapes in the cucurbits has been shown to have no relation at all to the shape of the cells which compose them, these cells being of essentially the same shape (chiefly isodiametric) in all races. Differences in organ shape are thus related to numbers of cells in the various dimensions.

Shape differences occur independently of the size of the fruit (and thus of the total number of cells which compose it). The single-gene difference between "disk" and "sphere" shape expresses itself against many genetic backgrounds and in a wide range of sizes, and is inherited quite independently of fruit size. In more complex cases of shape inheritance, size and shape seem also to be quite independent genetically. This is indicated by the facts that when races differing in both fruit size and fruit shape are crossed, (a) the F_2 shows no correlation between size and shape; (b) there is a positive correlation between length and width in pure lines and F_1 , but a negative correlation in F_2 ; and (c) length and width are equally variable

THE COLLECTING NET was entered as second-class matter July 11, 1935, at the Post Office at Woods Hole, Mass., under the Act of March 3, 1879, and was re-entered on July 23, 1938. It is devoted to the scientific work at marine biological laboratories. It is published weekly for ten weeks between July 1 and September 15 from Woods Hole, and is printed at The Darwin Press, New Bedford, Mass. Its editorial offices are situated on Main Street, Woods Hole, Mass. Single copies, 30c; subscription, \$2.00.

in pure lines and F_1 , but length is twice as variable as width in F_2 .

2. *Internal Differentiation.*—During fruit development the various tissue layers change in relative volume. Tissue volumes have been measured, and since cell volumes here are known, cell numbers for the various tissues can be calculated for different stages. It is found that the rate of increase in cell number, and thus in rate of cell division, is the same for all tissues. (Incidentally, cell number tends to increase in direct proportion to increase of ovary surface). Differences in cells and tissues are thus a result of cell enlargement only, proceed to a considerable degree even though the rate of cell division is the same throughout the entire organ.

4. *Planes of Cell Division.*—By measuring the angles which the axes of the mitotic figures make with the axis of the developing ovary, it may be shown that differences in shape are related to differences in planes of cell division. In fruits where length and width are known to grow at equal rates, cell division occurs in all directions with equal frequency. In races where length grows faster than width, the majority of the mitotic axes are not very far from parallel with the ovary axis, thus increasing the number of cells in the longitudinal direction faster than in the transverse one. This might seem to indicate that ovary (and fruit) shape is ultimately under the control of the behavior of individual cells. There is evidence, however, that the plane of division of a given cell is determined, in part at least, by factors other than those within its own organization. In the Indian snake gourd, *Trichosanthes*, which reaches about two meters in length by only five centimeters in width, growth in length is very much more rapid than in width, and practically all the new cell walls are at right angles to the fruit axis. The cells are thus in regular longitudinal rows, much as in the fundamental tissues of root and stem, but are meristematic throughout. Opportunity is thus provided for comparing the angles at various stages of mitosis with the final position of the figure as shown by that of the new wall. When the angles of the mitotic axes in this species were measured, it was found that the metaphases were distinctly variable in angle, though the bulk did not deviate more than 40° from the ovary axis. In the anaphases, the variability and deviation were less, and in the telophases, the great majority of divisions were nearly parallel to the axis. At the time of wall formation the approximation was even closer. The axes are evidently fluctuating in their orientation during early mitosis but gradually settle down to a fixed position as division becomes complete. The situation somewhat resembles that in a series of swinging magnetic needles which finally come to rest in a position determined by the magnetic field in which they

lie. Other facts also suggest that the plane of cell division is controlled by factors not situated in the individual cell.

Evidence from all these sources therefore supports the idea that development of the organ is, at least to a great extent, independent of the manner in which it is divided into cellular units. Organization at one level, in such a view, is independent of organization at another level, and division into cells, although conferring physiological advantages in making differentiation possible, is not of profound morphological or developmental significance. With this general conclusion most students of development will probably agree.

If development is not the result of mutual cellular interaction, however, it must be explained on other grounds, a task which involves many difficulties and in which little substantial progress has as yet been made. An important contribution to physiological genetics has been the proof that diffusible substances, controlling pigment production and certain other characters, are formed under the influence of genes; but for such substances to be of morphogenetic significance it is essential that they be distributed, in time and space, according to a definite pattern. The mechanism of such control is quite unknown. Specifically morphogenetic substances, notably the animal organizer, have been postulated, and the biochemical aspects of this problem were recently discussed here by Dr. Needham. There is also the possibility that there may be a relation between organic form and the specific shapes of protein molecules, as has been suggested by Harrison and others, or that the shape and character of colloidal particles may play a part here; but direct evidence for this hypothesis is as yet slight.

Many workers today are looking less hopefully to purely chemical factors for an explanation of development than to more strictly physical ones. Thus the importance of what are termed "morphogenetic fields" has been frequently emphasized. Evidence that such entities exist and can be analyzed has been presented by many workers, and the electrical phenomena associated with them have been studied by Burr. The field concept is still necessarily rather vague, and in the minds of many it carries certain mystical implications. We may think of a field, however, in more direct and familiar terms if we look upon it as merely the sum of the physiological reactions which an entire system makes with its environment. Here again the body of one of the higher plants provides helpful material. This body, although much less highly organized than the animal body, does show, in most species, a definitely controlled size and form which is characteristic. Body size is primarily a function of the rate and duration of photosynthetic activity, the efficiency of intake of mineral nutrients, and the synthesis of living material from

these two sources. The available amount of an essential hormone may also be important, as has been shown to be the case in differences between normal and dwarf varieties of maize. Body form is similarly a result of general physiological factors. Whatever controls the development and relative growth of buds in various parts of the plant will markedly affect plant form; and it has been shown in a number of cases that the difference between a tall, unbranched race and a shorter, bushy one with many branches is primarily in the production of auxin, which in turn controls bud development. The reaction to gravity, as shown in angle of branching and other respects; the reaction to light, as shown in relative growth in length of terminal and lateral shoots, in etiolation, and other ways; and the efficiency of transport of material, especially water, which is affected in turn by osmotic concentration, vessel size, membrane permeability and other factors, are all physiological attributes of specific living material, and their combined effect is to produce a plant body of specific size and form, regardless of the way in which it is divided into cellular units. In some such way it seems possible that the size and form of individual organs may be brought about through the specific protoplasmic reaction of the entire mass of living material of which they are composed. We may call the ultimate morphogenetic

control a "field" without implying anything more recondite than a series of more familiar physiological reactions. Of course the possibility exists that operating underneath all this there may be a developmental pattern which is electrical or biochemical in character.

At any rate, it is clear that the problem of organic development should not be attacked entirely from the viewpoint of cellular structure and cellular physiology as such, but from a study of larger masses of organized living material which have a unitary and specific developmental history of their own which is as significant as that of the simpler cellular units. What is obviously needed here is the accumulation of an immense number of new facts as to normal and experimentally controlled development, and an attempt at their interpretation. This is one of the central tasks of biology, and here it is that morphology, physiology, cytology, embryology, and genetics, together with biochemistry and biophysics, approaching the problem from their diverse viewpoints, unite in a common purpose. Whether we work with genes or with chromosomes or with cells or with organs and organisms, we are all concerned with the same fundamental problem, that of the development of coordinated but integrated organic systems.

(This article is based upon a lecture given at the Marine Biological Laboratory on August 25.)

PITHECANTHROPUS AND SINANTHROPUS, THE MOST PRIMITIVE HOMINID TYPES KNOWN HITHERTO, AND THEIR RELATIONSHIP TO LATER STAGES OF EVOLUTION

DR. FRANZ WEIDENREICH

Cenozoic Research Laboratory, Peiping Union Medical College, Peking, China

The first discovery of an almost complete brain case of *Sinanthropus pekinensis* demonstrated the close relationship existing between this hominid type and the Java Man, *Pithecanthropus erectus*. Additional finds of *Sinanthropus* material confirmed the first impression, but on the side of *Pithecanthropus* Dubois' famous skull cap remained the only one for a long time. Thanks to the never slackening endeavor of Dr. R. von Koenigswald, however, we possess today three more brain cases of *Pithecanthropus*, one upper jaw and a lower one. These remainders reveal that *Pithecanthropus* represents a real hominid with his general character closely related to *Sinanthropus* but more primitive than the latter in regard to certain features. This is especially true of the upper jaw and the just recently recovered skull belonging to one and the same individual (*Pithecanthropus* IV). There is, for instance, a wide gap between the canines and incisors; the proportions and arrangements of the molars likewise recall the great apes. The skull is of an enormous length combined with an amazing lowness and crowned by a high, broad and massive crest.

Pithecanthropus and *Sinanthropus* represent a special group among the fossil hominids, which may be specified as "Prehominids", according to Boule's classification. Morphological differences, however, justify allotting the two types to two different sub-types or races.

The new *Pithecanthropus* material strengthens also the suggestion that *Homo soloensis* (*Javanthropus*) has to be regarded as a more advanced *Pithecanthropus* corresponding to the next phase of evolution represented by the Neanderthal Man in the European line. This relationship proves that at least in Java we are dealing with a special line of human evolution restricted to this territory. One single center where all of mankind originated never existed. Man must have developed from different centers distributed over the world, each branch taking its own course more or less independently of the others. The result of this trend is manifested by the existence of the various races of today.

(This article is based upon a lecture given at the Marine Biological Laboratory on August 24.)

IN MEMORY OF DECEASED MEMBERS OF THE CORPORATION OF THE MARINE BIOLOGICAL LABORATORY

Memorials Adopted at the Annual Meeting of the Corporation, August 8, 1939

CHARLES RICHARD CRANE

Charles Richard Crane was born in Chicago, Illinois, August 7, 1858, and died this year. His interest in this Laboratory began approximately in 1901 when he was elected a member of the Corporation and a Trustee. But even before that date he had personal contacts with the work of the Laboratory which continued throughout his life. He became President of the Corporation in 1903, succeeding Professor H. F. Osborn, who resigned at that time. As soon as he became a Trustee he identified himself with the ideals and interests of the Laboratory.

His benefactions began in 1901, through personal gifts. When the contributions from the Carnegie Institution that extended from 1903 to 1905 came to an end, the Laboratory lived from hand to mouth, as it were, depending on its friends to cover its growing deficits. From 1910 to 1924 Mr. Crane, by most generous gifts, carried the burden of operating deficits almost alone. In addition he presented the first permanent building in 1913. In 1924 and 1925, in conjunction with the Rockefeller Foundation, Mr. John D. Rockefeller, Jr., and the Carnegie Corporation, Mr. Crane contributed largely to the erection and equipment of the second permanent building and to a sufficient endowment for future operations.

Quoting Dr. Lillie:

The history of the institution would have been very different indeed if it had not been for Mr. Crane. His support gradually developed confidence in the soundness of the institution, even though managed by professors, and was a major factor in securing large gifts from the Rockefeller Foundation, Mr. John D. Rockefeller, Jr., the General Education Board and the Carnegie Corporation.

At the dedication of the Crane Laboratory in 1914 Mr. Crane said:

I think we have come here particularly to celebrate the wonderful spirit that is back of the Woods Hole Biological Laboratory. It is very difficult to define that spirit, but I think we all know something of it and something is also known all through the scientific world. Without that spirit no amount of bricks and mortar and organization would be of any great service, but with that spirit the laboratory has been able to accomplish a very great deal with very simple means. (Director's Report for 1914, Biological Bulletin, Vol. 28, No. 6, 1914, p. 345.)

Dr. Lillie commented recently: "This statement, characterized by brevity, appreciation of others, understanding of aims, and quiet humor gives admirably the spirit that animated all his acts for the Laboratory."

Let me quote, again, from Mr. Crane's address in 1925 on the occasion of the dedication of the second permanent laboratory.

Even though not personally associated with the vital processes of the laboratory it has been the greatest possible privilege to play the part of a simple spectator in watching the growth of the wonderful spirit of cooperation in the work of biological research.

Some years ago the then business manager of the Rockefeller Institute for Medical Research invited me to spend the evening with him and try to help him understand the nature and conditions of the spirit of the Marine Biological Laboratory. 'For,' said he, 'we all recognize that the spirit is there. It is the rarest thing that we know of, and we have many discussions as to its nature and the conditions under which it has come forth.' He then asked me if I had any theory about it. I answered that the essential thing, as it seemed to me, was that it was the purest expression of the highest form of democracy—a form of Soviet directed by the highest rather than the lowest motives . . .

We all know that this spirit which we are so much concerned about has long been domesticated in the old buildings across the street and among the older biologists. Although the street is a very narrow one, the mission of inviting the spirit of the laboratory into the new and more modern buildings and giving it a longer lease of its great power is mainly up to the younger biologists now coming along. Much power to them! (From Science, Vol. 62, 1925, 271-272.)

When in 1925 Mr. Crane resigned as President of the Trustees he wrote:

Twenty-two years have now elapsed since I became President of the Marine Biological Laboratory. I have enjoyed with you watching the growth of the Laboratory during that period. With the strong interest and support that is now assured, I feel that my own work has been completed and I hereby tender you my resignation which I ask you to accept . . .

And he added:

The future progress and prosperity of the Laboratory will always be a matter of great interest to me, quite as much as if I continued to be your President.

Other gifts he has made from time to time, most of them of great value to the Laboratory, but the gift that the members of the Laboratory will cher-

ish as being the greatest was his appreciation and understanding of the work that has been carried on in the Marine Biological Laboratory.

EDMUND BEECHER WILSON

Edmund Beecher Wilson was born in Geneva, Illinois in 1856, a son of Isaac G. Wilson and Caroline Clark Wilson. He attended Antioch College, the old University of Chicago, and the Sheffield Scientific School of Yale where he obtained the degree of Bachelor of Science in 1878; and three years later the degree of Ph.D. at Johns Hopkins University. He then studied in Cambridge, England, in Leipzig, and in Naples. During this period he made deep and lasting friendships with many of the leaders of European biology, Boveri, Butschli, Dohrn, Driesch, R. Hertwig and many others.

On returning to America Wilson lectured for a year at Williams College and at the Institute of Technology. From 1885 to 1891 he was Professor of Biology at Bryn Mawr College. He was then called to Columbia University as Adjunct-Professor of Biology. Later he became Professor of Invertebrate Zoology, and then da Costa Professor of Zoology, holding the latter position until he was retired in 1928 with the title Professor Emeritus of Zoology in Residence in Columbia University. He died in New York City on March 3rd last.

Wilson's connection with the Marine Biological Laboratory began almost at its start in 1888, becoming a Trustee in 1889 and remaining on the Board for the remainder of his life. Keenly interested in the welfare of the Laboratory, he took an active part in all the meetings of the Board.

Active and vigorous in youth and middle age he was ready for athletic activity of all kinds but bicycling, tennis and golf were the sports that he apparently liked best. His sensitive, artistic nature found ample expression in music and for many years not only did he patronize the musical centers of New York but he was a devoted and excellent cello player, a member of a well-known New York string quartet, and a prominent member of the musical circles of that city.

He was a member of all of the leading learned Societies of this country and Europe, and the recipient of innumerable honors here and abroad. He was the Croonian lecturer for the Royal Society in 1914. But, significant as these are, he will be lovingly remembered by his many friends by the distinction of his mind and personality. His scientific keenness, judgment, and breadth of knowledge, were shown by the perfection of his lectures and papers.

He was the recognized leader in cytological research. His book on "The Cell in Development and Heredity" remains and will long remain, a

classic in this field. The American School of Cellular Research was, in large part, the outcome of his influence. His many devoted students and friends will remember him as their ideal of a scientific worker and charming companion.

WALTER OTIS LUSCOMBE

For forty-three years Walter O. Luscombe has been an interested member of the Corporation of the Marine Biological Laboratory. He joined in 1896 at a time when the Laboratory needed friends and encouragement, before its future had been assured by a large and devoted membership of biologists and by contributions of substantial buildings and endowment.

Mr. Luscombe sensed the worth of the struggling institution that was seeking to make its home in his community, and his request for membership in the Corporation is to be viewed as the action of a responsible citizen giving public expression to the interest and good will of the whole community.

He died in July in his 88th year.

We shall miss him from our Annual Meetings which he regularly attended and we find satisfaction in recording our appreciation of his kindly interest and good will.

CALVIN BLACKMAN BRIDGES

Dr. Calvin Blackman Bridges died on December 27, 1938, just a few days before reaching the age of 50 years.

Dr. Bridges first came to the Marine Biological Laboratory in 1912, while he was still an undergraduate. For the next twenty years he regularly spent the summers at Woods Hole, where much of his work on the genetics and cytology of *Drosophila* was done.

Dr. Bridges had an unrivalled familiarity with this material, and one of his outstanding characteristics was his readiness to help other workers by supplying laboriously prepared material and by giving freely of his time in an advisory capacity. His scientific work was a conspicuous example of the unselfish cooperation that is one of the ideals of the Marine Biological Laboratory.

CHARLES RUPERT STOCKARD

The Corporation of the Marine Biological Laboratory records with profound regret the death on April 7th, 1939 of Charles Rupert Stockard, a member of this scientific body since 1908 and an active participant in its affairs through a consecutive service of nineteen years on its board of Trustees.

Professor Stockard was born in Washington County, Mississippi, and his father was a practi-

tioner of medicine. At an early age he was thus brought in touch with many of the every-day aspects of human biology and the sociological problems of the community. This heritage and these early experiences left imprints of deep significance in his life which in later years he frequently commented on; sometimes blending them into present day situations and at other times contrasting them in effective and meaningful ways.

A preliminary college education in the Mississippi Agricultural & Mechanical College was completed in 1899 and soon thereafter he entered graduate work at Columbia University. In 1906 he became associated with the teaching staff of Cornell Univ. Medical College. He was made Assistant Professor of Embryology in 1909 and two years later he was appointed Professor of Anatomy and Director of that department, a post he held for the remaining years of his life. Coincident with his academic assignments he maintained a vital interest in the Marine Biological Laboratory. This Institution held for him a peculiarly deep seated significance and he was wont to recall his early associations here; also, the friendships with his old teachers, with his contemporaries, and with the group of younger biologists.

A bibliography covering a wide range of topics in the fields of cytology, embryology, genetics, endocrinology, medicine and education conveys at once an idea of Professor Stockard's versatility and symbolizes in a concrete way something of the genius, the originality, and the scholarliness of his mind. Approximately thirty-five of his earlier papers deal with problems on regeneration and the artificial production of structural anomalies in lower forms. His commanding knowledge of these problems was reflected prominently in much of his later work and teachings.

Endowed with an engaging personality his passing brings also a loss far greater than is indicated by mere scientific achievement. A free and entertaining conversationalist he was able to turn to the lighter sides of life with facility and enjoyment, and to witticisms of the most humorous nature. A mind ready to challenge any height, and prompt to champion any cause he believed to be right. Withal he possessed a keen sense of scientific values, an incisive way of thinking and an unadorned form of expression.

In Charles Rupert Stockard, death has taken from this Corporation of the Marine Biological Laboratory, one of its staunchest champions, one of its most faithful servants and helpful mentors.

JAMES PLAYFAIR McMURRICH

James Playfair McMurrich, emeritus Professor of Anatomy in the University of Toronto, died February 9, 1939 in his seventy-ninth year. He was born and educated in Toronto and received

his early training in zoology there; he obtained his Ph.D. degree in zoology at Johns Hopkins University in 1885. He received the honorary degree of LL.D. from the University of Michigan in 1912, from the University of Cincinnati in 1923 and from the University of Toronto in 1931. He held numerous offices in scientific societies, including the Presidency of the American Association for the Advancement of Science in 1922.

His entire life was one of great scientific activity in research, teaching, and administration. He was primarily a zoologist; although the greater part of his life was spent as Professor of Anatomy in a medical school he never took a medical degree. He published 107 scientific papers from 1882 to 1932, was the author of two text books well known in their time, "Invertebrate Morphology" (1894) and "Development of the Human Body" (1903), and edited two treatises on human anatomy. His research interests were wide, ranging from Coelenterates, Molluscs, Crustacea and Ascidians to various vertebrate groups; and in the last years of his life, the history of anatomy.

At the Marine Biological Laboratory we remember him best in his invertebrate days. He came to the Marine Biological Laboratory first in 1889 while serving as an associate of Professor Whitman in Clark University. In that year, and for two succeeding years, he was instructor in the course in Invertebrate Zoology. He delivered evening lectures on "The Phylogeny of the Actinozoa" (1889), "The Gastrea Theory and its Successors" (1890) and on "The Significance of the Blastopore" (1891). He was a member of the Corporation from 1890 to the time of his death, and from 1892 to 1901 he was a member of the Board of Trustees. His withdrawal from active participation in the affairs of the Marine Biological Laboratory was a natural consequence of the change in direction of his scientific work to Anatomy in relation to medicine.

It is many years since McMurrich was actively concerned in our affairs, though his interest was lifelong; but there are still some of us who remember him at Woods Hole as a quiet, courteous gentleman and scholar, loyal to the interests of the Laboratory, a good friend, fond of life and sports, and withal of exceptionally fine character and quality.

EDWIN LINTON

Professor Edwin Linton, a member of the Corporation of the Marine Biological Laboratory since 1898, died in Philadelphia June 4, 1939, in his eighty-fifth year. He came to Woods Hole first in 1882 and worked in the Laboratory of the United States Fish Commission temporarily located on the Buoy Wharf at Little Harbor. At the time of his death he was the last survivor of

that original band of investigators who first brought biology to this immediate shore. From these early times till his death Dr. Linton was an unremitting student of the parasites of fishes, a subject to which he made many valuable and original contributions. Although his researches were carried out in the Laboratory, of the Bureau of Fisheries he always took a keen and active interest in the affairs of the Marine Biological Laboratory. He became a corporate member of this institution in the year when by invitation most of the workers at the Fisheries Laboratory joined this Corporation whose annual meetings he regularly attended.

He was a familiar figure to all who came to the Woods Hole laboratories. He took a lively interest not only in the general scientific activities of the community but also in its play. He was a

skilled actor, the first president of the reorganized M.B.L. Club, and an enthusiastic member of the Choral Club. He and his wife established at Washington and Jefferson College the "Edward S. Linton Memorial Endowment" in memory of their son who gave his life in France during the World War. The income from this endowment is paid to the Marine Biological Laboratory and has been the means of enabling not a few students to work here. This and other generous acts associated with Dr. Linton's name will long be remembered. Dr. Linton's sense of social obligation led him always to be a willing participant in any movement for the general good. In fact it was in a step to protect others that he met with the accident that cost him his life. We mourn his loss as that of an earnest, scientific worker and of a generous and loyal associate.

LIVING CELLS IN ACTION DEMONSTRATED IN MOTION PICTURES

(Continued from page 189)

include examples of extension, retraction, irritation, autotomy, and new growth cone differentiation following loss by phagocytosis. Several cases are given which reveal how red blood cells that have been extruded from blood vessels are engulfed by macrophages.

Various types of behavior of localized contraction nodes in single muscle fibers (from *Palaeomonetes* leg and *Limulus* heart) are also presented. These include their formation, progression, splitting, reflection, collision, and dissipation; also their progression past thin clots resembling intercalated discs.

Other pictures (obtained with the cooperation of Dr. Ethel Harvey) show the early develop-

mental history of the sea urchin *Arbacia*, including immature egg, mature egg just before and just after fertilization, segmentation stages from 1 to 64 cells, free swimming gastrula, and pluteus. Other pictures show abnormal cleavages of centrifuged eggs and of the clear halves of centrifuged eggs.

Polariscopic pictures reveal the birefringent substances in pigment cells, epithelial cells, muscle fibers during contraction and relaxation, and in the developing eggs and larvae of *Arbacia*.

(This article is based upon motion pictures presented at the Marine Biological Laboratory on August 21.)

MICROMANIPULATIVE STUDIES

DR. ROBERT CHAMBERS

Research Professor of Biology, New York University

The film is one which was assembled to illustrate a lecture on "The Micromanipulation of Cells" given at the Cell Symposium held at Leland Stanford University from June 29 to July 6 of this year.

Most of the scenes in the film have already been shown here. They deal with the effect of puncturing and tearing various living cells such as plant root hairs, amoeba and echinoderm eggs, and also echinoderm eggs undergoing cleavage. These have been done in collaboration with Mr. C. G.

Grand. One scene was taken by Dr. W. Duryec showing the extensibility of chromosome filaments removed from the germinal vesicle of an Amphibian ovarian egg. Among the scenes not previously shown here are those taken by Dr. M. J. Kopac and show the coalescence or engulfment of oil drops by *Arbacia* eggs when the oil is brought into direct contact with the surface of the naked eggs.

(This article is based upon motion pictures presented at the Marine Biological Laboratory on August 21.)

The Collecting Net

A weekly publication devoted to the scientific work at marine biological laboratories.

Edited by Ware Cattell with the assistance of Boris I. Gorokhoff and Mona Garman.

Entered as second-class matter, July 11, 1935, at the U. S. Post Office at Woods Hole, Massachusetts, under the Act of March 3, 1879, and re-entered, July 23, 1938.

Introducing

DR. MAX PERROT, Instructor at the Station de Zoologie expérimentale, University of Geneva, Switzerland.

Dr. Perrot is visiting the United States for a period of five months, mostly during the vacation at the University of Geneva. He arrived in the United States at the end of April of this year, and worked for some time at the American Museum of Natural History in New York. He also visited the Museum of Comparative Zoology at Cambridge and the Natural History Museum at Philadelphia before coming to Woods Hole in June.

Born in Geneva, Dr. Perrot attended the University in that city, receiving his doctorate of philosophy there in 1938. In preparation for his degree he made a comparative study of the cytology of land-snails. Since then he has been working in cytology, and has studied problems of sexuality and genetics in molluscs. At the Marine Biological Laboratory this summer he has been working in the library as well as preparing mollusc material for study in Europe.

Dr. Perrot plans to sail for Europe at the beginning of October and will return to the University of Geneva in time for its opening this fall. He will remain in Woods Hole until the middle of September.

The visitors signing the register at the Bureau of Fisheries station totalled 9195 during the last month.

The Rockefeller Foundation has granted Stanford University the sum of \$200,000 for the continued maintenance, during a ten-year period, of a program of biological research which has been supported since 1934 by previous grants from the same foundation.

DATES OF DEPARTURE OF INVESTIGATORS

Alley, A.	August 30
Angerer, C. A.	August 26
Badger, E. A.	August 30
Barden, R.	August 21
Beck, L. V.	August 28
Boell, E. J.	August 21
Brownell, K. A.	August 30
Calabrisi, P.	August 31
Campbell, J.	August 30
Clutton, R. F.	August 24
Curtis, W. C.	August 30
Duggar, B. M.	August 29
Edds, M. V.	August 25
Frisch, J. A.	August 28
Genther, T.	August 25
Goodrich, H. B.	August 31
Grinnell, S. W.	August 30
Hartman, D. M.	August 31
Haywood, C.	August 26
Hendricks, E. M.	August 29
Kindred, J. E.	August 30
Parker, G. H.	August 30
Pemberton, F. A.	August 31
Rabinowitch, E.	August 29
Reinstein, C.	August 31
Ruebush, T. K.	August 29
Rynbergen, H.	August 26
Shaw, Myrtle	August 30
Snedecor, J.	August 23
Van Heuverswyn, D.	August 21
Von Dach, H.	August 29
Walker, P. A.	August 30
Weissenberg, R.	August 22
Wenrich, D. H.	August 30
Wherry, J. W.	August 25

CURRENTS IN THE HOLE

At the following hours (Daylight Saving Time) the current in the Hole turns to run from Buzzards Bay to Vineyard Sound:

Date	A. M.	P. M.
September 2	7:06	7:28
September 3	7:47	8:07
September 4	8:26	8:57
September 5	9:13	9:45
September 6	10:03	10:40
September 7	10:59	11:39
September 8	11:57	.....
September 9	12:43	1:01
September 10	1:43	2:03
September 11	2:39	2:57

In each case the current changes approximately six hours later and runs from the Sound to the Bay.

ITEMS OF INTEREST

DR. OSCAR E. SCHOTTÉ, professor of biology at Amherst College, has just made known his marriage to Mrs. Anna Pearce Munsell on June 12 in Chicago. She is the daughter of Dr. William H. Pearce. Mrs. Schotté, who has been living in Longmeadow, Mass., graduated from Goucher College in 1924.

MISS PHYLLIS FRANKEL and MR. DANIEL PEASE were married in Falmouth recently. Mr. Pease is a research assistant in biology at Princeton, and both he and Mrs. Pease have been working at the Marine Biological Laboratory this summer.

DR. R. E. COKER, head of the department of zoology and chairman of the division of natural sciences of the University of North Carolina, has been made Kenan professor of zoology in place of the late Professor H. V. Wilson.

DR. MORRIS H. HARNLY has been promoted from assistant to associate professor of biology at New York University.

DR. VIVIAN TROMBETTA, who has been assistant in botany at Barnard College, has been appointed instructor in botany at Smith College.

MISS HAZEL GOODALE has been appointed an assistant in the Department of Physiology of the University of Maryland School of Medicine.

DR. CHARLES M. BREDER has been made a research associate in the Bingham Oceanographic Laboratory at New Haven, Conn. He has been acting director of the New York Aquarium.

DR. AND MRS. MCKEEN CATTELL visited Woods Hole on Thursday and Friday.

DR. WM. H. PETERSON, professor of agricultural Bacteriology at the University of Wisconsin, arrived in Woods Hole on August 23 to visit for ten days with scientists at the Marine Biological Laboratory and the Woods Hole Oceanographic Institution.

DR. FLORENCE PEEBLES, professor of zoology at the University of California has been at the Marine Biological Laboratory for the last two weeks.

PROFESSOR AND MRS. JAMES DAVIDSON of the University of Adelaide, South Australia, is visiting Woods Hole for several days. Professor Davidson is working in the field of entomology.

MISS VIRGINIA HARFORD, of the staff of the Baker-Hunt Foundation Natural History Museum in Covington, Kentucky, completed a two months' visit to Woods Hole on Thursday.

DR. CLAUDE E. ZOBELL, who has been working at the Woods Hole Oceanographic Institution this summer, left early this week to attend the meetings of the International Society of Soil Science in New Brunswick, N. J., and the International Congress for Microbiology in New York City.

DR. ADAM BOVING, senior entomologist of the United States National Museum, retired, arrived in Woods Hole with his wife last week-end for a stay of a week and a half.

DR. JOHN S. BUCK, research assistant in embryology at the Carnegie Institute, presented an illustrated lecture at the M.B.L. Club on Thursday evening on "Mountaineering in the Tetons."

The lecture "Congo Color" was given by Mr. Duncan M. Hodgson on Friday evening instead of Thursday evening as originally scheduled.

At the staff meeting of the Woods Hole Oceanographic Institution last Thursday, Mr. Floyd M. Soule presented a paper entitled, "Applied Physiological Oceanography on the International Ice Patrol."

DR. E. NEWTON HARVEY, professor of physiology at Princeton University, is the author of an article in the August 25 issue of *Science* on cameras for deep sea photography.

The meeting of the International Union of Geodesy and Geophysics will be held as scheduled, despite reports that the convention has been postponed because of the international situation. Several members of the Woods Hole Oceanographic Institute have gone to Washington to present papers.

The Seventh International Genetics Congress was held at Edinburgh from August 23 to 30, although the program was seriously curtailed because of the international tension preceding the present hostilities in Europe. Soviet delegates announced their withdrawal from the Congress on August 22, the Germans left on August 25, the French on August 26, the Italians on August 27, and by the end of the Congress there was only one member, a Swede, present from continental Europe. However, the American contingent, numbering about 130, together with the British delegates carried out the program of the Congress, which ended a day early. Dr. F. A. E. Crew acted as President after the withdrawal of Professor N. I. Vaviloff of Russia, who was to have been president. A number of the American delegates are now stranded in Scotland because of the difficulty of obtaining passage on ships due to the outbreak of hostilities.

NEUTRALIZATION OF ACTION OF DEPRESSANTS UPON NERVE INJURY POTENTIALS

DR. RITA GUTTMAN

Tutor in Physiology, Brooklyn College

Macdonald early in this century was able to show that when he placed frog nerve in solutions of certain inorganic substances, such as KCl, the resting potential dropped, that is, approached zero potential. Moreover, he found a direct relationship between the magnitude of the potential and the logarithm of the concentration of the bathing solution, which was in agreement with the theory of concentration cells then lately proposed by Nernst. A few years ago Cowan was able to demonstrate the same concentration effect in non-medullated crab nerve, when using isotonic KCl.

That the depressing effect of KCl upon the potential could be neutralized in frog nerve by applying an isotonic solution of the chloride of an alkaline earth simultaneously with KCl was demonstrated by Höber and Strohe in 1929. If a mixture of BaCl₂ or some other alkaline earth plus KCl was applied to frog nerve the potential did not drop, while if KCl was applied alone, it did. All solutions were, of course, isotonic with frog Ringer's solution.

Recently, Höber and his co-workers have been able to show that certain lipoid soluble, surface active, highly polar substances, which in some cases may possibly have some similarity to metabolites released by the nerve cell during activity, are also able to depress the potential, just as KCl does. This has been demonstrated both for medullated frog nerve and non-medullated crab nerve.

The experiments being reported were all done upon the non-medullated nerve of the proximal segment of the first walking leg, or of the claw, of the spider crab, *Libinia canaliculata*. Salt bridges lead from an injured end and the treated middle portion of the nerve to calomel electrodes, which were connected to a potentiometer and null point galvanometer. All solutions used were approximately isotonic with sea water and pH was controlled.

In themselves, the alkaline earths, Ba, Sr, Ca and Mg, in isotonic solutions of their chlorides, have practically no effect upon the injury potential of spider crab nerve. The alkaline earths have, however, a definite stabilizing influence upon the membrane with the result that the usual depressing action upon the potential of K is ineffectual in lowering the injury potential when a solution containing both K and the alkaline earth ion is applied to the nerve. Ba, Sr and Ca are not equal in their stabilizing power. Solutions containing two parts of BaCl₂ to one part of KCl,

five parts of SrCl₂ to one part of KCl, and eleven parts of CaCl₂ to one part of KCl are threshold values for the neutralization effect. The order of effectiveness of the alkaline earths for counteracting the depression of the potential by KCl is thus Ba, Sr, Ca. This is the order in which these elements appear in the atomic table. Whether or not this is of any significance is hard to say.

It was of interest next to investigate whether the alkaline earths are capable of preventing depression of the potential by the organic depressants. It was found that the alkaline earths are capable of preventing the lowering action of such an organic depressant as veratrine sulphate. A 0.00004 M solution of veratrine sulphate in sea water depresses the injury potential markedly, yet when a 0.00004 M solution of veratrine sulphate in isotonic BaCl₂, SrCl₂, CaCl₂ or even MgCl₂ is applied to the nerve, the membrane seems to be somehow stabilized against the effect of the veratrine sulphate.

Various other organic depressants, chloral hydrate, iso amyl urethane, sodium salicylate and saponin, can be neutralized by the alkaline earth Ba. There has as yet been no opportunity to investigate the other alkaline earths in this regard. In the preliminary experiments, the agents were permitted to act only a short time since it was felt that interpretation would be simpler if irreversible effects were avoided. However, the experiments were recently repeated using longer times in order to investigate the duration of the neutralizing effect of the alkaline earths. It was found that the effect may last for many hours. It was also established that the alkaline earths are capable of preventing the action of depressants strong enough to cause, when present alone, a decrease of potential of fifty per cent or more.

Since it had been fairly well established that the alkaline earths could neutralize the depressing effect of organic substances as well as of K, it was decided to investigate quantitatively the depressing action of one of these organic depressants, *viz.* veratrine sulphate. When the change in potential which occurs when veratrine sulphate has been acting upon the nerve for fifteen minutes is plotted against the logarithm of the concentration of the solution acting, a straight line seems best to fit the points. Just as the direct relationship between potential drop and logarithm of concentration was found by Macdonald for various inorganic substances acting upon medullated frog nerve and by Cowan for KCl acting upon crab nerve, so it can

be demonstrated that in crab nerve there is a direct relationship between drop in potential and concentration of veratrine sulphate acting.

Although we obtain a concentration effect with both K and veratrine it is not necessary to assume that the action of these substances upon the nerve is identical. Indeed, it probably is not. It should be noted that the relative concentration of KCl (one part isotonic KCl to eleven parts sea water, or 0.04 M) necessary to depress the potential is of a much greater order of magnitude than that of the organic substances (*e.g.* 0.00004 M veratrine sulphate).

It may well be that the measured injury potential is not due to one factor alone, but is the resultant of a number of factors such as concentration differences, polarization and possibly others. It is not at present possible to say whether the agents used in these experiments affect one of these factors or another. However, it might be well to examine some of the theories advanced in explanation of injury potential phenomena.

Höber and his school have emphasized the possible sieve-like structure of the membrane. Höber believes that the order of effectiveness of different ions upon the injury potential in general depends upon ionic volume and that deviation from this rule can probably be accounted for by the action of the ions upon the membrane, *e.g.*, changing pore size, charge, etc. A possible explanation for the alkaline earth neutralization of the depressants would then be that the alkaline earths may change the effective pore size in a sieve-like membrane and thus prevent depression.

In opposition to the pore theory of membrane structure Osterhout has long held that the membrane may be regarded as a non-aqueous phase immiscible with water, and that potential differences may be considered to arise primarily from diffusion potentials. On this basis he was able to calculate the mobilities of ions in protoplasm and came to the conclusion that guaiacol changes the apparent ionic mobilities of Na and K in various

unicellular plants. Osterhout and Hill suggest that Ca can reduce the partition coefficient of KCl in *Nitella*. On the basis of Osterhout's findings then, it might be suggested that in these experiments on crab nerve, the alkaline earths may be decreasing the partition coefficients of KCl and of the organic substances and thus preventing the depressing action of these substances.

Whatever the theoretical explanation invoked to describe the action of the alkaline earths in preventing depression of the potential, the phenomenon is by no means one of antagonism in the classical sense of Jacques Loeb, for the following reasons. First, the quantities of alkaline earths necessary are much greater than in Loeb's experiments. Secondly, in Loeb's experiments each of the antagonizing ions was in itself poisonous and together they had no poisonous effect. In the work here reported only one of the agents depresses the potential and when both act together the potential is not depressed. The word "neutralization" describes the phenomenon rather better than "antagonism."

To summarize, the alkaline earths, which in themselves have no effect upon the injury potential of non-medullated spider crab nerve, are capable of preventing depression of the potential by K and by various organic substances. The phenomenon is not one of antagonism in the sense of Loeb. Two possible explanations for the effect are the following. The alkaline earths may prevent action of the depressants either (1) by altering effective pore size in a sieve-like membrane or (2) altering partition coefficients of the depressants. While the data do no violence to either of two current conceptions of the membrane: ((a) a sieve-like membrane and (b) a water immiscible phase between aqueous solutions), neither do they on the other hand favor either one exclusively.

(This article is based upon a seminar report given at the Marine Biological Laboratory on August 22.)

PAPERS AND DEMONSTRATIONS PRESENTED AT THE GENERAL SCIENTIFIC MEETING, 1939

Tuesday, August 29, Morning Session, 9:00 A. M.

D. P. COSTELLO and R. A. YOUNG: The mechanism of membrane elevation in the egg of *Nereis*.

EDGAR ZWILLING: Determination and induction of the anuran olfactory organ.

ETHEL BROWNE HARVEY: A method of determining the sex of *Arbacia*, and a new method of producing twins, triplets and quadruplets.

ETHEL BROWNE HARVEY: An artificial nucleus in a non-nucleate half-egg.

G. H. PARKER: Color responses of catfishes with single eyes.

GRACE TOWNSEND: The function of the vibration sense in *Nereis limbata*.

D. H. WENRICH: Food habits of *Endamoeba muris*.

J. E. KINDRED: A quantitative study of the hemopoietic organs of young albino rats.

WILLIAM H. F. ADDISON: The histology of the mammalian carotid sinus.

ALEXANDER SANDOW: On Clark's theory of muscular contraction.

- F. J. M. SICHEL: The refractory period in the non-conducted response of striated muscle.
- ALICE M. RUSSELL: Pigment inheritance in the *Fundulus-Scomber* hybrid.
- J. D. CRAWFORD and A. E. NAVEZ: Conditions determining the frequency of contraction of the Venus heart.
- Tuesday, August 29, Afternoon Session, 2:00 P. M.**
- VIRGINIA SAFFORD: The use of the swimbladder by fish in respiratory stress.
- HERBERT SHAPIRO: Water permeability of *Chaetopterus* eggs.
- M. H. JACOBS and A. K. PARPART: A mechanism of increased cell permeability resembling catalysis.
- M. E. KRAHL, A. K. KELTCH and G. H. A. CLOWES: Oxygen consumption and cell division in fertilized *Arbacia* eggs in the presence of respiratory inhibitors.
- M. G. NETSKY and M. H. JACOBS: Some factors affecting the rate of hemolysis of the mammalian erythrocyte by *n*-butyl alcohol.
- J. B. S. CAMPBELL and M. H. JACOBS: Studies on the permeability-decreasing effect of alcohols and pharmacologically related compounds on the human erythrocyte.
- RICHARD G. ABELL: Quantitative studies of the passage of protein and other nitrogenous substances through the walls of growing and of differentiated mammalian blood capillaries.
- Wednesday, August 30, Morning Session, 9:00 A. M.**
- ERIC G. BALL and BETTINA MEYERHOF: The occurrence of cytochrome and other haemochromogens in certain marine forms.
- CARL C. SMITH and DAVID GLICK: Some observations on cholinesterase in invertebrates.
- KENNETH BAILEY: Crystalline myogen.
- J. H. HUTCHENS and M. E. KRAHL: Effect of increased intracellular pH on the physiological action of substituted phenols.
- AURIN M. CHASE: Color changes in luciferin solutions.
- FRED W. ALSUP: Photodynamic action in *Neureis* eggs.
- IRVING COHEN: Cleavage delay in *Arbacia punctulata* eggs irradiated while closely packed in capillary tubes.
- RUBERT S. ANDERSON: The X-ray effect on the cleavage time of *Arbacia* in the absence of oxygen.
- P. S. HENSHAW: Fixation of X-ray effect by fertilization in *Arbacia* eggs.
- WILLIAM R. DURYEE: Does the action of X-rays on the nucleus depend upon the cytoplasm?
- A. E. NAVEZ: Fatty acid compounds in the *Arbacia* egg.
- A. A. ABRAMOWITZ: A new method for the assay of intermedin.
- FLORENCE ARMSTRONG, MARY MAXFIELD, C. LADD PROSSER and GORDON SCHOEPPLE: Analysis of the electrical discharge from the cardiac ganglion of *Limulus*.
- ROBERT BALLENTINE: The intra-cellular distribution of reducing systems in the *Arbacia* egg.
- H. W. BEAMS and T. C. EVANS: Some effects of colchicine upon the first division of the eggs of *Arbacia punctulata*.
- E. FRANCES BOTSFORD: Temporal summation in neuromuscular responses of the earthworm, *Lumbricus terrestris*.
- F. A. BROWN, JR.: The source of chromatotropic hormones in crustacean eyestalks.
- F. A. BROWN, JR., and H. H. SCUDAMORE: Comparative effects of sinus gland extracts of different crustaceans on two chromatophore types.
- F. A. BROWN, JR., and H. E. EDERSTROM: On the control of the dark chromatophores of *Crago* Telson and Uropods.
- JOHN B. BUCK: Micromanipulation of salivary gland chromosomes.
- T. C. EVANS and H. W. BEAMS: Effects of Roentgen radiation on certain phenomena related to cleavage in *Arbacia* eggs.
- JOHN D. FERRY: Chemical and mechanical properties of two animal jellies.
- JUDITH E. GRAHAM and F. J. M. SICHEL: Response of frog striated muscle to CaCl_2 .
- CHARLOTTE HAYWOOD: The permeability of the toadfish liver to inulin.
- JOSEPHINE HOLLINGSWORTH: Activation of *Cumingia* and *Arbacia* eggs by bivalent cations.
- DWIGHT L. HOPKINS: The vacuole systems of a fresh water limacine *Amoeba*.
- CORNELIUS T. KAYLOR: Cytological studies on androgenetic embryos of *Triturus viridescens* which have ceased development.
- VALY MENKIN: Effect of leukotaxine on cellular permeability to water.
- VALY MENKIN: Effect of leukotaxine on cell cleavage.
- FLOYD MOSER and J. A. KITCHING: Response of the *Arbacia* egg cortex to chemical and physical agents in the absence of oxygen.
- S. MILTON NABRIT: Further studies on regeneration in *Fundulus* embryos.
- A. J. WATERMAN: The action of certain drugs on the intact heart of the compound ascidian, *Perophora viridis*.
- OPAL WOLF: An effect of the injection of a solution of dihydroxyestrin into castrated female frogs, *Rana pipiens*.

Papers Read by Title

- R. K. ABRAMOWITZ and A. A. ABRAMOWITZ: Moulting and viability after removal of the eyestalks in *Uca pugnator*.

Demonstrations

Wednesday, August 30, 2:00 P. M.

- BETTINA MEYERHOF and E. G. BALL: The cytochrome spectra in squid heart.

ETHEL BROWNE HARVEY: a) Serial photographs of normal development of *Arbacia*.
b) New photographs of parthenogenetic mero-gones of *Arbacia*.
c) Twins, triplets, and quadruplets of *Arbacia*.
d) Stratified echinoderm eggs.

WILLIAM H. F. ADDISON: Photographs and drawings illustrating the normal histology of the albino rat.

C. LLOYD CLAFF: A migration-dilution apparatus for sterilization of Protozoa.

A. E. NAVEZ: The set-up for the study of Venus hearts.

R. L. CARPENTER and H. R. SWEET: Dissection

of eyes and brain of a 350 pound swordfish.

C. C. SMITH: The use of the clam heart as a test object for cholinergic drugs.

KENNETH BAILEY: Myogen crystals.

E. R. CLARK and E. L. CLARK: Transparent chambers installed in rabbit's ears.

R. G. ABELL: a) An R. G. Williams transplant chamber.

b) A new type of filter disc chamber for collection of capillary filtrate.

GRACE TOWNSEND: The vibration sense in *Nereis limbata*.

E. A. WOLF and MARYON M. DYTCH: Apparatus for blood calorimetry.

"HOW THINGS GROW" AND "RAPIDLY MOVING CELLS"

DR. W. J. BAUMGARTNER

Professor of Zoology, University of Kansas

The film "How Things Grow" is a series of film strips showing the behavior of green cells in two species of grasshoppers. Its purpose is to act as a teaching film illustrating mitosis.

The movement of the chromatin granules is shown in growing stages. The gathering of the chromatin into chromosomes, and the equatorial plates are shown several times. The movement of the chromosomes to the poles and the constriction of the mother cell into daughter cells can be repeatedly followed. The second spermatocyte as well as the spermatogonial divisions are presented but not as frequently as the first division.

The various shapes of the chromosomes are very evident, as well as the mitochondrial threads, the spindle and the interzonal fibers.

The film shows very distinctly the bubbling activity at the poles during late anaphases and early telophases. The genus *Steccobothrus* has very marked polar activity while in *Mermira* it is slight.

The cells are teased from the follicular tubicles of testes dissected from the last instar nymphs and

the pictures are taken by slow motion and speeded up approximately 40 times when shown at the usual rate (16 frames per second).

The film of "Rapidly Moving Cells" is a series of strips of very rapidly moving cells teased from the testes of the American cockroach *Periplaneta americana*.

The cells vary much in shape and type of movement and leave the photographer in doubt as to the nature of these cells. Many characteristics indicate that these cells are transforming spermatids, probably somewhat abnormal. Other cells look much like blood cells which may have adhered to the testes. For either interpretation, the unusual thing is the rapidity of the movement. Other transforming spermatids have very slowly writhing, growing tails. Blood cells have slow movement changing their shape and justifying their being called "Protean" cells by insect histologists.

(This article is based upon motion pictures presented at the Marine Biological Laboratory on August 21.)

INVERTEBRATE CLASS NOTES

Wednesday morning Dr. Kille modestly enumerated the artful adaptations of the arthropods—their chitinous exoskeleton, their striated musculature, and their economic importance. Our day was spent in exploring the structure of the lobster, the blue crab and *Artemia*; we determined to know them intimately, down to the last intestinal coil.

Evening found us still assiduously at work until the tinkle of the Good Humor Man's troika broke the silence. Then the room was darkened and from the store room emerged a large pink and white birthday cake bearing 28 lighted candles. Amidst shouts of "Happy birthday," there was a mad scramble down to the table of "Alabama" Kincaid. It was his birthday and the Invertebrates resolved that it should be celebrated appropriately. After a general distribution of crumbs

of cake and ice cream, we retired to the street to dance the Virginia Reel. "I had to come to Cape Cod to learn the Virginia Reel," exclaimed one Southerner.

The following day "Alabama" received a letter from his wife. "Yesterday was your birthday, I hope you remembered to celebrate!"

Dredging and towing were voted the most restful of field trips. Sitting on a deck, crushing bryozoan nodules, is exceeded only by examining tow microscopically as a means of relieving muscular fatigue.

The second in a series of lectures on Marine Ecology was delivered by Dr. Hadley on Monday morning. The subject of deeper waters and their inhabitants proved very interesting indeed. We heard of *Ceracia*, the deep sea female who fastens a dwarf male to her forehead ("This will serve as

a warning to young men to keep out of deep water"); of the exploded Mermaid myth; and of the flickering fireworms of the balmy Bermudas.

At the close of the lecture we found the *Wini-fred* and the *Mary II* waiting for us at the dock, so off we steamed to Hadley Harbor. The mud there impressed itself upon our memory: we waded in it to our knees; it broke our shovels; it got in our hair; it removed our shoes—but it did yield Annelids, Upogebia, Thione, and for one team (Dr. Rankin's) 135 specimens.

We exhibited our haul in the main lobby—the various teams taking turns at the chore of chang-

ing water. Team 4 found that it was slated to do its duty at 12 P. M. They solved the problem by holding a party at Becky DuBois' till midnight, at which time they returned to MBL only to find that a missing member of their team had changed most of the water already.

Milestones of the week: Ruth Rayburn departs for U. of Cal.; Elmer Bueker, for Washington U.; Elizabeth Zabelin, for Chicago; Frank Marzulli removed his beard and thereby won a bet of \$1.50. Dick Egan revealed a hitherto unknown tonsorial talent in his operations upon Jack Cavender's potential Van Dyke.
—Irene Ehrmann

M.B.L. TENNIS CLUB

With the playing of the men's and women's singles finals last Saturday, the following came through as the champions of the 1939 season of the M.B.L. Tennis Club:

Men's singles—Dr. T. K. Ruebush.

Women's singles—Miss Ruth Ellen Musser.

Men's doubles—Dr. Bradley Patton and Dr. T. K. Ruebush.

Women's doubles—Mrs. Dorothy Norman and Mrs. Helen Highet.

Mixed doubles—Dr. T. K. Ruebush and Miss Ruth Ellen Musser.

Junior singles—Huntington Mavor.

In the men's singles, Ruebush demonstrated his marked superiority over the rest of the field and finished off with love set victories over Wickendon in the finals. Ruebush gained the finals by defeating Herriott 6-2, 6-2, while Wickendon overcame Kaylor in love sets.

In the women's singles finals, Miss Musser's all-around game was too much for Miss Ramsdell, whose weak backhand allowed Miss Musser to gain a forecourt position from which she consistently put away winners. The final score was 6-1, 6-3. Miss Musser narrowly escaped being eliminated in the semi-finals by Mrs. Highet, win-

ning 2-6, 7-5, 6-4 in a hard fought match. Miss Ramsdell gained the finals by defeating Mrs. Borden 6-2, 7-5.

The junior singles brought out some very fine tennis on the part of the finalists, Huntington Mavor and Patsy Saunders, the former winning 7-5, 6-3 to gain the Saunders cup.

In the doubles events, the most hotly contested match took place in the mixed doubles, with Dr. Ruebush and Miss Musser prevailing over Dr. and Mrs. Lancefield 6-2, 7-9, 6-1 before a large and appreciative gallery. The winners will hold the W. E. Strong cup for the year.

The finals of the men's doubles resulted in a 6-4, 6-3 win by Patton and Ruebush over Lancefield and Krahle.

The women's doubles championship was decided in the second semi-final match when Mrs. Norman and Mrs. Highet defeated Miss Voter and Miss Poole in love sets. The other finalists, Mrs. Jones and Miss TeWinkel, were forced to default when Mrs. Jones suffered a sprained wrist during a mixed doubles match.

The finals in the Falmouth Heights tournament resulted in a win for two M.B.L. Tennis Club members when Drs. Ruebush and Lancefield won the men's doubles championship.—R. L. Carpenter

BEACH IMPROVEMENT FUND

Members of the Committee for the Bay Shore Bathing Beach Improvement Fund, which is seeking to raise one thousand dollars for the construction of a jetty on the M.B.L. Bathing Beach have been recently announced. They are Mrs. H. H. Fay, Dr. Frank R. Lillie, James McInnis, Capt. John Veeder, Dr. Eliot R. Clark, Mr. C. G. Grand, and Miss Joan Pecheux.

The jetty, which will extend 150 feet at right angles into the water, is expected to gather sand and cover up the ever-present rocks on the beach. For one thousand dollars Contractor S. W. Lawrence has also agreed to remove the large rocks which are now acting as breakwater and in their place deposit sand from the numerous sand bars in the water.

A benefit dance for the Bay Shore Bathing

Beach Improvement Fund was held at the Breakwater Hotel last Tuesday evening. Proceeds from the dance amounted to \$240. Music was played by Cliff Martell and his 6-piece orchestra.

The donation to the Laboratory of Dr. Oliver S. Strong's property, which lies adjacent to the M.B.L. Beach and which has been always open to the public through Dr. Strong's kind permission, was announced by Professor Chambers, master of ceremonies, at the dance.

Especial thanks are given to Dr. Strong for his kindness in donating the property to the Laboratory. The Committee also wishes to express its deep appreciation for a check of \$100 donated by Dr. W. C. Curtis. The Committee announces that the Bathing Beach Improvement Fund now totals \$350.
—Brad Chambers

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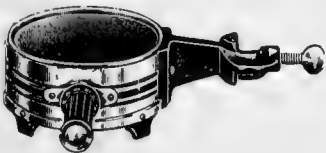
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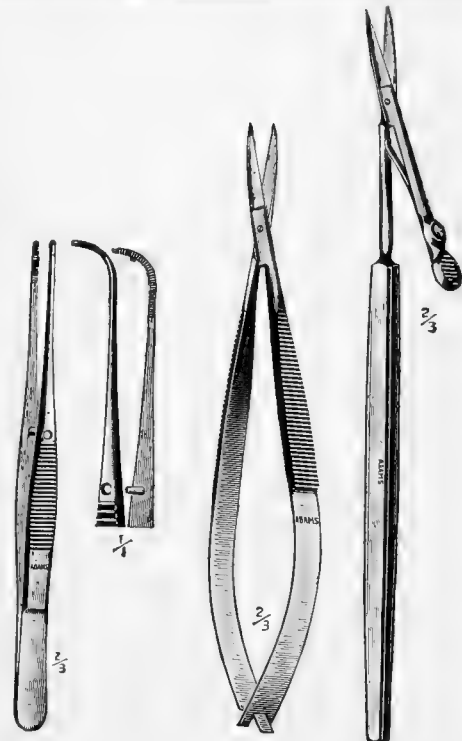
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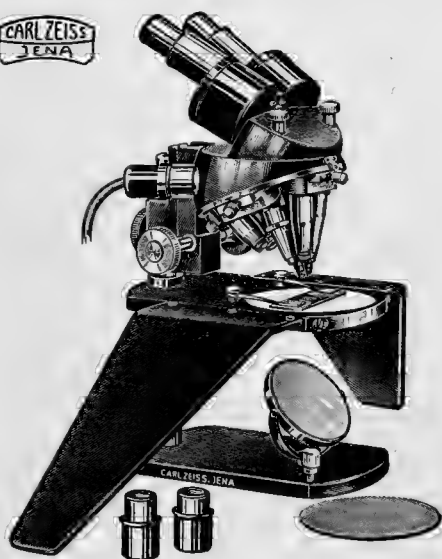
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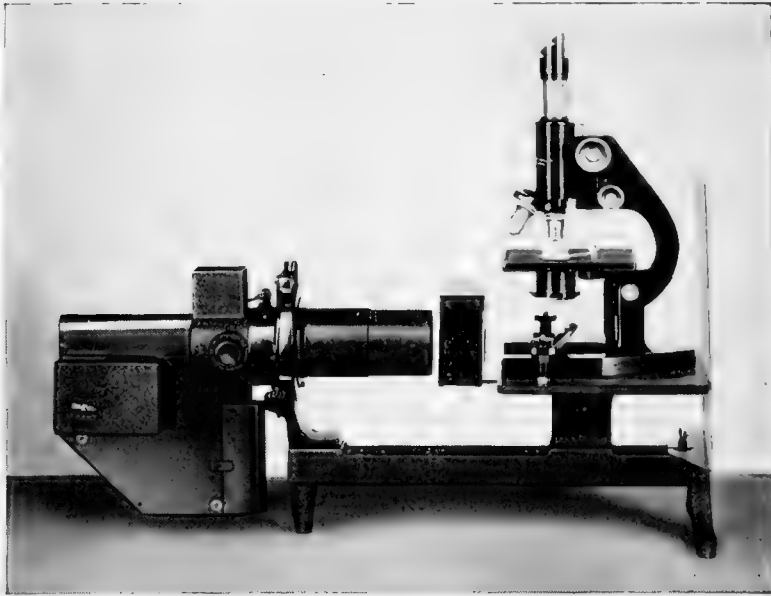
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